METAL PROGRESS

MARCH - 1950

AN IMPORTANT MESSAGE TO METAL WORKERS INTERESTED IN:

SPINNING, BLANKING, STAMPING, MACHINING, ETC.

1. FORM THIN SECTION PARTS OF **LOW CARBON STEEL**
2. HEAT TREAT FORMED PARTS TO INCREASE CARBON TO A **MEDIUM OR HIGH CARBON STEEL**

A *New* HEAT TREATMENT

Homogeneous Carburization

Broadens the Scope of Production of Small Metal Parts

In homogeneous carburization the carbon content is built up throughout the entire thickness of the steel. The carbon potential of the prepared gas atmosphere is adjusted equal to the carbon desired in the steel. Then the low carbon steel is heated in this atmosphere where the carbon content gradually raises until the equilibrium is established between the atmosphere and the steel being treated.

RX Gas Atmosphere

A 'Surface' RX Gas atmosphere is used for the process. 'Surface' RX Gas generators have been used extensively in industry for gas carburizing, dry cyaniding, carbon restoration, and clean hardening. They have proved most satisfactory in operation since they maintain an output of prepared gas atmosphere of constant analysis with a minimum of adjustment and maintenance.

THE PROCESS:

Homogeneous carburization permits the transformation of a low carbon steel into a medium or high carbon steel, in parts of thin section, after fabrication, and oftimes during the final step of heating for hardening.

BEFORE Fabrication of low carbon steel (1/16" section) before heat treatment. 100X—nital etch.

AFTER 1/16" section homogeneous carburized throughout at 1700°F. in RX Gas atmosphere with a 0.60% carbon potential. Oil quenched. 100X—nital etch.

Continuous or Batch Type Furnaces

Either continuous or batch type furnaces can be used that have a heating chamber suitable for complete exclusion of both air and flue gas. Modern 'Surface' radiant tube heated furnaces, which have the necessary safeguards for good atmosphere control, are most applicable to this new process.

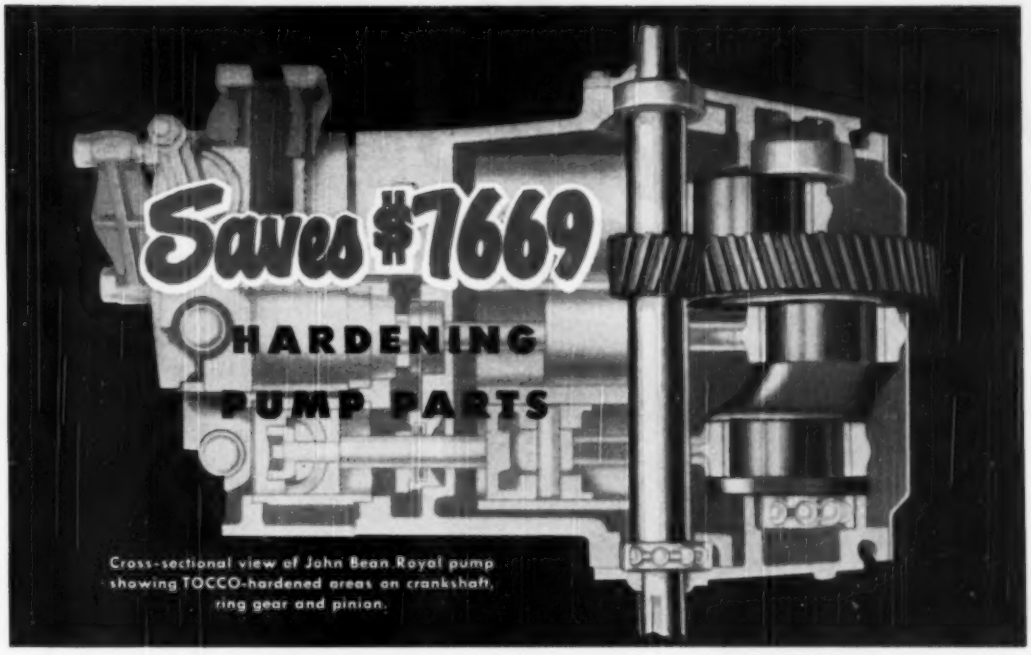
'Surface' Research and Development

The principles of carbon balance which have been so well applied to 'Surface' gas carburizing to permit control of surface carbon concentration, regardless of case depths, have been just as satisfactory adapted to homogeneous carburization at any desired carbon level from low and medium carbon to 1.00% carbon and higher if required.

WRITE FOR COMPLETE DETAILS... NO OBLIGATION

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES



Cross-sectional view of John Bean Royal pump showing TOCCO-hardened areas on crankshaft, ring gear and pinion.

with TOCCO* Induction Heating

Progressive engineers at John Bean Manufacturing Company recently adopted TOCCO Induction Heating for hardening vital parts on famous Royal high pressure pumps. The annual savings of $7669 is typical of the experience of thousands of metal-working plants who have adopted economical TOCCO for hardening, brazing, soldering, and heating for forging.

TOCCO IS ECONOMICAL—Cost of heat-treating parts shown was cut from $3.51 to 95¢ when TOCCO replaced conventional heat-treating methods.

TOCCO IS DEPENDABLE—Rejects due to variation in heat-treating are eliminated because TOCCO is automatic—produces identical results—one part or a million.

TOCCO IS FAST—Hourly production rates of the crankshaft are 40 per hour, of the ring gear 25 per hour, and the pinion 20 per hour.

TOCCO IS VERSATILE—One unit, a 125 K.W., 10,000 cycle TOCCO machine hardens all these parts, and also shrink-fits gear to eccentric shafts.

Our Engineers can probably find applications in your plant, too, where TOCCO can increase output and cut unit costs. Having such a survey made costs you nothing—and may save you a great deal.

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today

NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-3, Cleveland 1, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating".

Name _____
Position _____
Company _____
Address _____
City _____ Zone ____ State _____

NEW STEEL FOR LONGER DIE LIFE...

BR-4*

*U. S. Pat. Applied For.

DESEGATIZED BRAND

LATROBE'S *New*

HI-VANADIUM HI-CHROME DIE STEEL

The Latrobe Electric Steel Co. announces another fully-uniform DESEGATIZED BRAND STEEL — BR-4 . . . a new die steel for increased production on difficult abrasive jobs.

BR-4 is a high vanadium, high chromium die steel — developed by increasing the proportions of vanadium and carbon in conventional high carbon, high chromium steels. This addition results in a greater number of evenly dispersed vanadium carbides possessing **superior abrasive resistant qualities.**

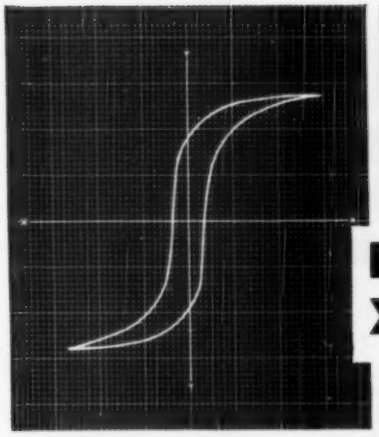
Die makers and users have found that **BR-4 outlasts** other types of die steels by at least **2 to 1** on jobs requiring high abrasive resistance. For **higher production** and **decreased die costs** . . . consult your LATROBE SERVICE ENGINEER on BR-4.

LATROBE ELECTRIC STEEL COMPANY

LATROBE, PENNSYLVANIA

BRANCH OFFICES AND WAREHOUSES LOCATED IN PRINCIPAL CITIES

See Latrobe's BR-4 display at the ASTE INDUSTRIAL EXPOSITION in Philadelphia, April 10-14. Stop in!!! . . . Learn how BR-4 can lengthen die life and decrease unit production costs.



NOW you can plot X vs Y... automatically

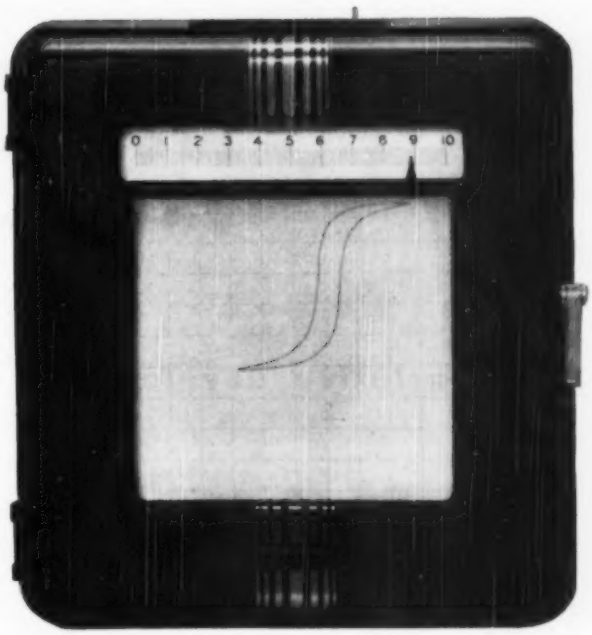
A new Speedomax Recorder . .

now automatically plots the relationship between two variables, showing one as a function of the other. Tedious compilation and manual plotting by experienced personnel are eliminated. Instead, the variables to be plotted are converted to d-c signals, and connected to the instrument, one to the horizontal axis and the other to the vertical axis. The result is a permanent record, accurately plotting in minutes data that would require hours using the point by point method.

As compared to the usual recorder, which has only one measuring circuit and a constant speed non-reversing chart paper drive and which plots a variable as a function of time, this new recorder has two measuring circuits. Pen travel (X axis) is controlled by our well known Speedomax G vacuum tube circuit. A similar circuit controls the chart paper drive, (Y axis) and makes it reversible. Thus, the new recorder makes it possible automatically to draw curves such as the hysteresis loop shown, temperature vs temperature difference, stress vs strain or other two-variable curves.

Response of the instrument is amply fast. The pen takes only 3 seconds for full scale travel of $9\frac{7}{8}$". Full chart travel is 10" and requires 4 seconds. Standard minimum voltage for full travel of either coordinate is 10 mv.

For further information, write to Leeds & Northrup Company, 4927 Stenton Avenue, Philadelphia 44, Pennsylvania.



Standard minimum range is 10 mv d-c for full deflection of either function.

Two electronic circuits—one for each function.

Large chart: about 100 square inches.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

1-(Ad ND663)

Metal Progress is published and copyrighted, 1950, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

if you always aim
for cleaner steels...
rely on
metal-cast
ferro-alloys
U. S. PATENT
2,197,660
an exclusive development of Ohio Ferro-Alloys!
Ferro-silicon 25, 50, 65, 75, 85, 90%
Special blocking 50% Ferro-silicon
Low Carbon Ferro-chrome Silicon
High Carbon Ferro-chrome
Ferro-manganese
Borosil
Simanal
PHILO
© OFA 1935
© OFA 1941
Ohio Ferro-Alloys Corporation
Canton, Ohio
Chicago Detroit Pittsburgh San Francisco Tacoma
BRIQUETS
SILICON • MANGANESE • CHROME
SILICO-MANGANESE

SALT BATH BRAZING

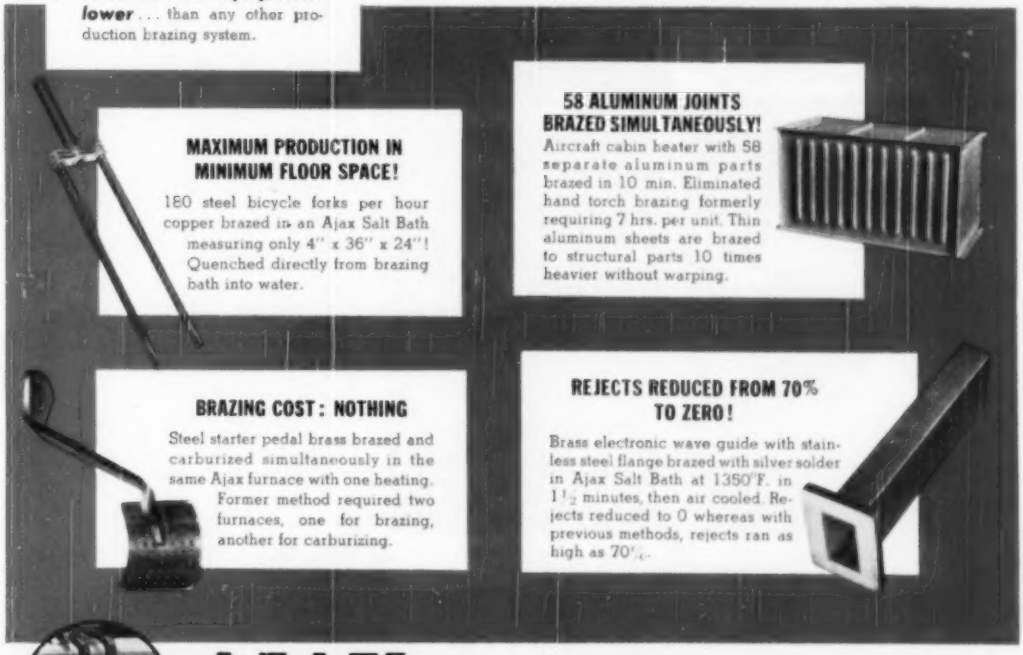
...the fastest, cheapest production method!

- ***Work immersed in batches*** ... 5, 20 or 100 assemblies in each batch.
- ***All joints brazed simultaneously*** ... in seconds rather than in minutes.
- ***Decarburization of steel assemblies avoided*** ... no reheating needed. Clean surfaces assured for subsequent processing.
- ***No cooling chamber required*** ... no hydrogen atmosphere. 75% less floor space!
- ***First cost of equipment lower*** ... than any other production brazing system.

Ajax pioneered the salt bath brazing technique and proved that most ferrous or non-ferrous assemblies in production quantities can be brazed far faster and more economically by this method than by any other. Today this method is widely used by leading fabricators on a wide variety of work for brazing steel, cast iron, copper or aluminum assemblies.

In cases where a brazed assembly must also be hardened or carburized, the salt bath offers special economies because the brazing and hardening can be done simultaneously in a single heating operation.

Let us braze a job batch of your parts in our Metallurgical Service Laboratory. See how much faster your work can be handled, how much your product can be improved. Write for details.



MAXIMUM PRODUCTION IN MINIMUM FLOOR SPACE!

180 steel bicycle forks per hour copper brazed in an Ajax Salt Bath measuring only 4" x 36" x 24"! Quenched directly from brazing bath into water.

58 ALUMINUM JOINTS BRAZED SIMULTANEOUSLY!

Aircraft cabin heater with 58 separate aluminum parts brazed in 10 min. Eliminated hand torch brazing formerly requiring 7 hrs. per unit. Thin aluminum sheets are brazed to structural parts 10 times heavier without warping.

BRAZING COST: NOTHING

Steel starter pedal brass brazed and carburized simultaneously in the same Ajax furnace with one heating. Former method required two furnaces, one for brazing, another for carburizing.

REJECTS REDUCED FROM 70% TO ZERO!

Brass electronic wave guide with stainless steel flange brazed with silver solder in Ajax Salt Bath at 1350°F. in 1½ minutes, then air cooled. Rejects reduced to 0 whereas with previous methods, rejects ran as high as 70%.

SELF-EVEN HEATING • SELF-CIRCULATING

AJAX ELECTRIC SALT BATH FURNACES

AJAX ELECTRIC COMPANY, Inc. 910 Frankford Avenue, Philadelphia 23, Pa.

THE WORLD'S LARGEST MANUFACTURER OF ELECTRIC HEAT TREATING FURNACES EXCLUSIVELY

In Canada: Canadian General Electric, Co., Ltd., Toronto, Ont.

Associate Companies: Ajax Metal Co. • Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.

See us at Booth 434, Tool Engineers Industrial Exposition, Philadelphia, April 10-14.

TAM* Zircon grog type ramming mix

Linings always last over 200 heats at Induction Steel Casting Company

Tapping Heat from 1000 lb. Allis-Chalmers Induction furnace at Induction Steel Casting Co.

*TAM zircon lining after drying out...ready for first melt.

Furnace ready for relining after 261 heats.

The experience of Induction Steel Casting Company of East Detroit, Michigan is typical of the extended lining service life that can be expected from TAM* zircon grog type ramming mix. Their lining life is always over 200 heats.

The 1000 lb. induction furnace shown here was used to melt 261 heats before relining was required. During this period, S.A.E. 1025 and 1030, 12% Cr. —1½%C., 4630, 6145 and die steel containing .50C. and 1.0% Cr. were the alloys poured.

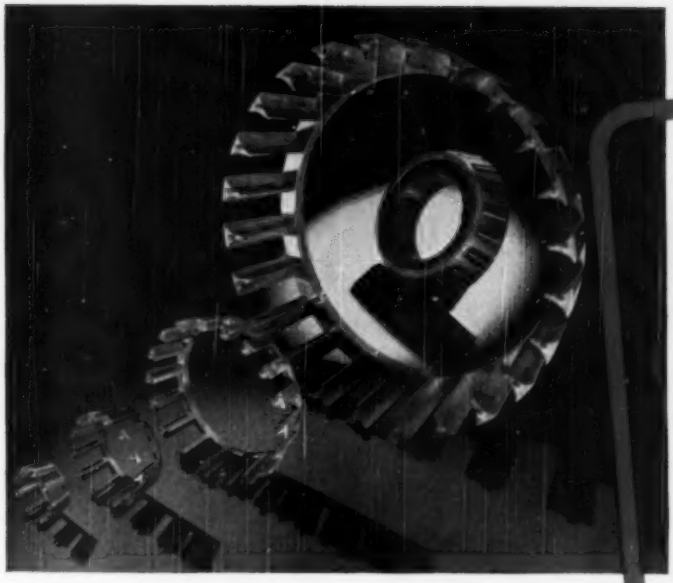
This long service and resultant increased furnace efficiency is due directly to the excellent resistance of TAM* lining material to high temperatures and erosive action. It explains why more metal is melted at less cost per ton when TAM* ramming mixes are used.

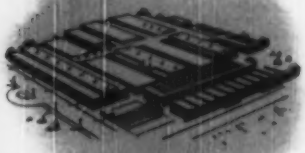
Detailed facts on TAM* ramming mixes may be obtained from our field engineers or by writing our New York office. It will pay you to have these facts.

TAM PRODUCTS
Registered U. S. Pat. Off.

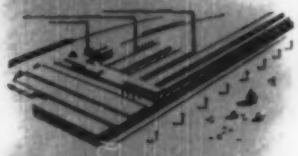
*TAM is a registered trademark

TITANIUM ALLOY MFG.. DIVISION
NATIONAL LEAD COMPANY
Executive and Sales Office: 111 BROADWAY, NEW YORK CITY · General Offices, Works, and Research Laboratories: NIAGARA FALLS, N.Y.

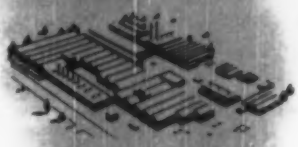




CLEVELAND, OHIO



DETROIT, MICHIGAN



BRIDGEPORT, CONN.

LOS ANGELES, CALIF.

Alcoa casts long runs at...

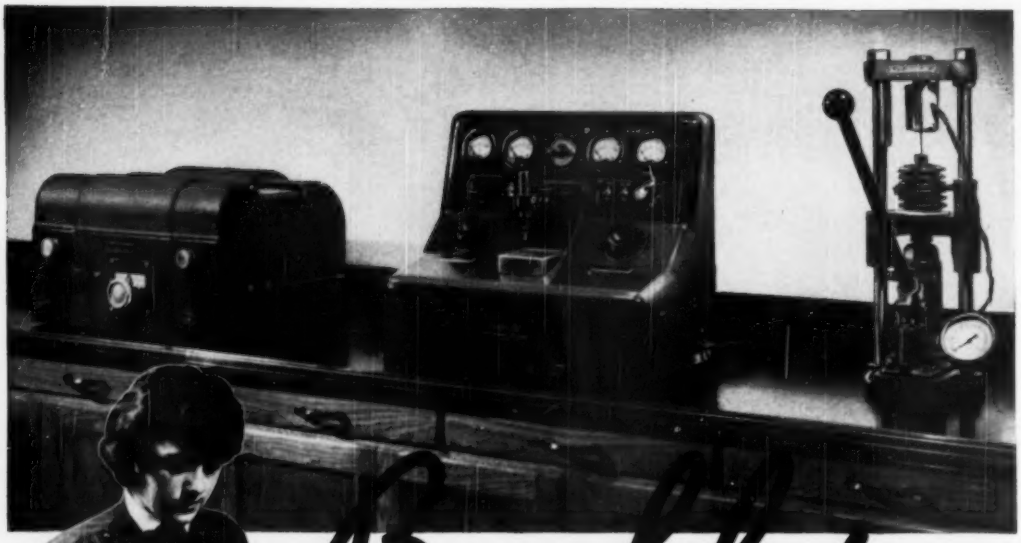
One of Alcoa's modern foundries is practically in your back yard. This fact puts at your disposal the most modern foundry equipment. Personnel who are old hands at light metal casting. 62 years of aluminum knowledge to improve your products.

When Alcoa casts your parts, they inherit more of aluminum's good points. Light weight. High strength. Corrosion resistance. And because of Alcoa's production facilities and experience, no one bids lower on the tough castings or the long run jobs. Sure, Alcoa casts the easy ones and the short runs, too. But we really shine on jobs that other foundries shy away from.

For a prompt quotation, call your local Alcoa sales office. It's listed under "aluminum" in your phone book. Or write ALUMINUM COMPANY OF AMERICA, 1993C Gulf Building, Pittsburgh 19, Pennsylvania.

ALUMINUM CASTINGS by ALCOA

ALCOA ALUMINUM



Buehler...

METALLURGICAL LABORATORY EQUIPMENT

. . . provides the metallurgist with the most complete line of modern designed precision machines for specimen mounting and preparation available anywhere in the world. This finely made equipment has been developed through a thorough understanding of the requirements of the metallurgist and a rigid insistance on perfection in the mechanical design and construction of each item.

Everything needed for metallurgical testing from cut-off machines, moulding presses, and grinders to the mechanical or electrolytic polishers is included in the Buehler line.

In setting up complete laboratories or adding items to present equipment the metallurgists will find in the Buehler line of coordinated equipment everything needed for producing the best work, with speed and accuracy.

Operator using the new Model No. 1506 low speed polisher. Section of laboratory equipped with No. 1251 Duo Belt Sander—No. 1700 Electro Polisher—No. 1315 Press.

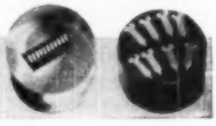
THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Write for bulletin of new equipment or information on any specific item. We invite correspondence relative to setting up complete laboratories suitable for any particular requirement.

Exclusive U. S. agents for Amsler and Chevenard Testing Machines.

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.



Are you using this helpful tool?...

. . . IT'S ONLY ONE OF REPUBLIC'S MACHINING AIDS FOR STAINLESS STEEL BAR USERS

There's no question about proper machining practices for Republic ENDURO Stainless Steel Bars when you use this handy *Cutting Speed and Feed Selector.* Simple to use, it gives recommended feed/speed ratios for eight different stainless steels, including the ENDURO Free-Machining grades.

Republic's other machining aids include personal contact assistance by veteran machining experts and stainless steel metallurgists. Whatever your problem involving the fabrication of stainless steel, these men are ready and well-qualified to help you find the most efficient and economical solution in a hurry.

If you do not already have your FREE *Cutting Speed and Feed Selector,* write today!

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Dept.: Chrysler Bldg., New York 17, N.Y.

Republic **ENDURO®**
FREE-MACHINING
STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

All-Inconel radiant tube assemblies for use in pit-type carburizing furnaces. The radiant tubes were assembled by the Industrial Fabricating Company, Toledo, Ohio. The short-radius Inconel return bends were fabricated by the Commercial Metal Spinning Company, Toledo, Ohio.

NOW

Low Furnace Operating Costs with ALL-INCONEL Radiant Tube Assemblies

In practical terms, the use of all-Inconel® radiant tube assemblies means longer tube life, less down-time for repairs, and lower fuel bills.

Inconel resists corrosion, embrittlement, and destructive oxidation at temperatures up to 2000°F. Welded joints in Inconel have the same desirable characteristics as the alloy itself. These features mean long life and low maintenance for your Inconel radiant tubes. And you get lower fuel bills because the light walls possible with heat-resisting Inconel radiant tube assemblies give faster heating and require less fuel to bring your furnaces to working temperature.

One of the important factors leading to the availability of all-Inconel radiant tube assemblies is the development of the fabricated Inconel short radius return bend.

The Commercial Metal Spinning Company, Toledo Factories Building, Toledo, Ohio, supply them to the following specifications:

3½ in. O.D., on 5½ in. centers
4½ in. O.D., on 8 in. centers
5½ in. O.D., on 8 in. centers

The O.D. sizes shown can be obtained on other center-to-center dimensions on special order. Fittings for tube sizes other than shown are presently being developed.

Cold-drawn Inconel seamless tubing is available in a wide variety of diameters and wall thicknesses to meet any requirements.

For specific information about Inconel radiant tube assemblies, write directly to Inco.

Remember, too . . . our Technical Service Department always welcomes an opportunity to help you solve high temperature and fabrication problems.

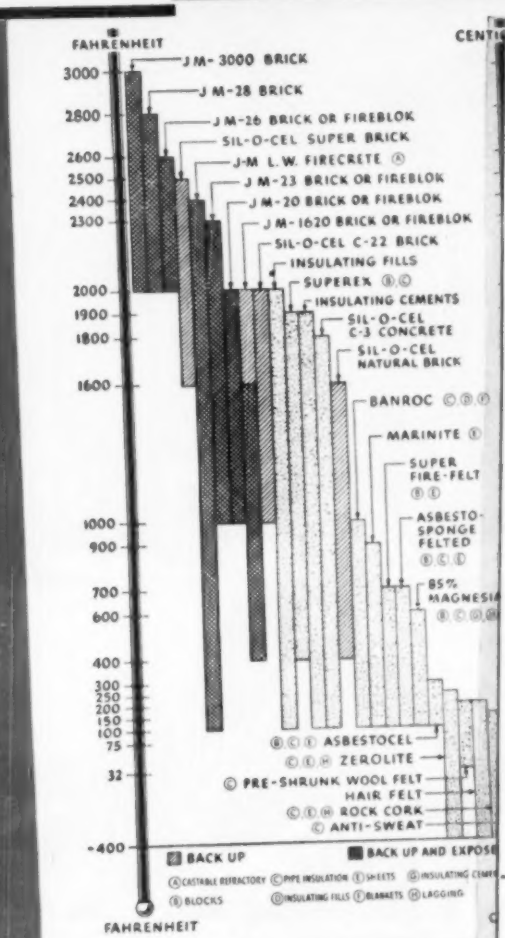
THE INTERNATIONAL NICKEL COMPANY, INC. • *67 Wall Street, New York 5, N. Y.*

EMBLEM OF SERVICE INCO TRADE MARK

INCONEL *. . . for long life at high temperatures*

Ready reference chart...

Johns-Manville THERMAL INSULATIONS



FOR EVERY TEMPERATURE JM EVERY

Yours... for better insulation service!

Now, you can see at a glance the recommended insulation for every temperature range, from minus 400F to plus 3000F.

It's all on this convenient Johns-Manville Thermal Insulation Chart (11½" x 18") available for hanging in your office or on your plant wall.

Each insulation in this group of Johns-Manville products is tailor-made to do a specific type of job *best*. And, as part of the Johns-Manville Insulation Service, specialists are available to help you with present insulation problems . . . or with those connected with future plans.

By having these men select and apply Johns-Manville insulations, you will be dealing with men who have grown up in the business. You'll find that it will pay, in the long run, to have these experts help you... *because they have to their credit more man-hours of insulation application experience than all other similar types of organizations combined.*

For your copy of this chart, just fill in and mail the coupon below.

Johns-Manville
Box 290
New York 16, N. Y.

Please send me copy of Johns-Manville Insulation Chart IN-6D.

Name_____

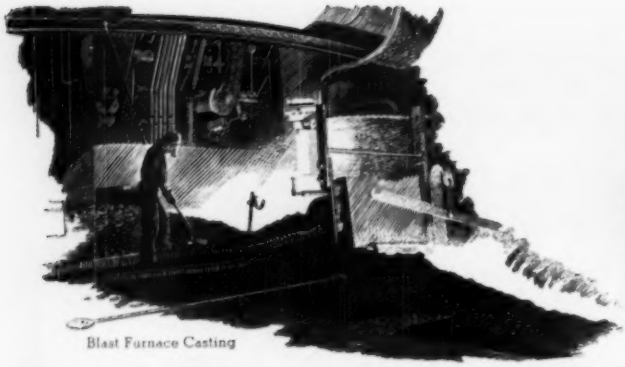
Title_____

Company_____

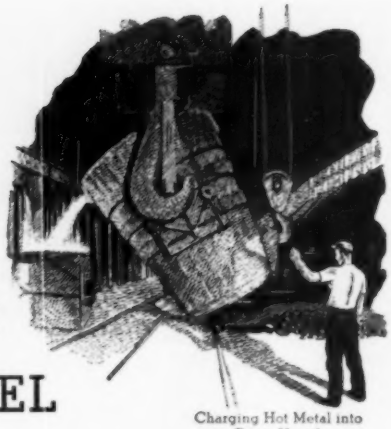
Address_____

City_____ State_____

MP-3



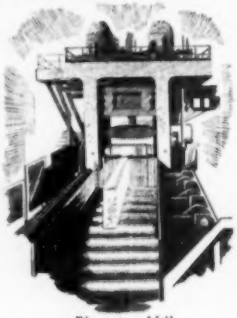
Blast Furnace Casting



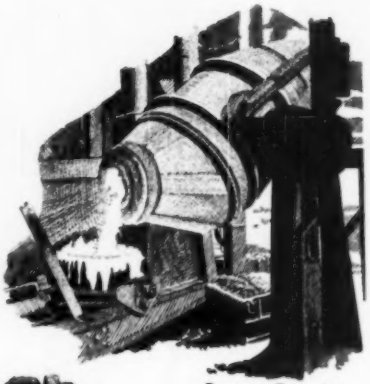
Charging Hot Metal into Open Hearth

AS GOOD AS THE STEEL
from which they are drawn

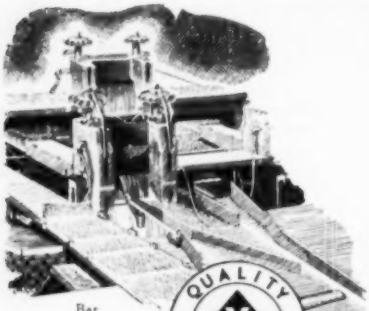
THE experience of nearly 50 years in producing Youngstown Steel in grades and analyses to meet our customers' most exacting requirements is your best insurance of the high quality of Youngstown Cold Finished Bars.



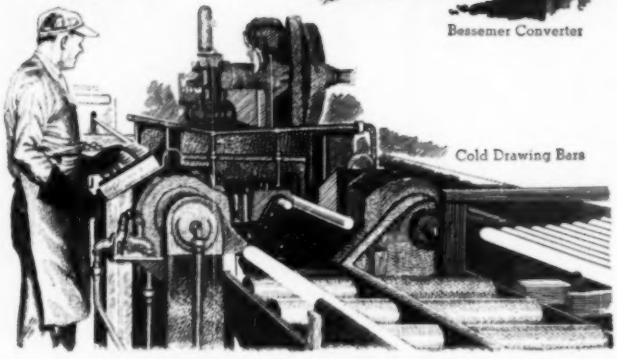
Blooming Mill



Bessemer Converter



Bar Mill



Cold Drawing Bars

QUALITY YOUNGSTOWN SERVICE

Youngstown
COLD FINISHED CARBON AND ALLOY STEEL BARS

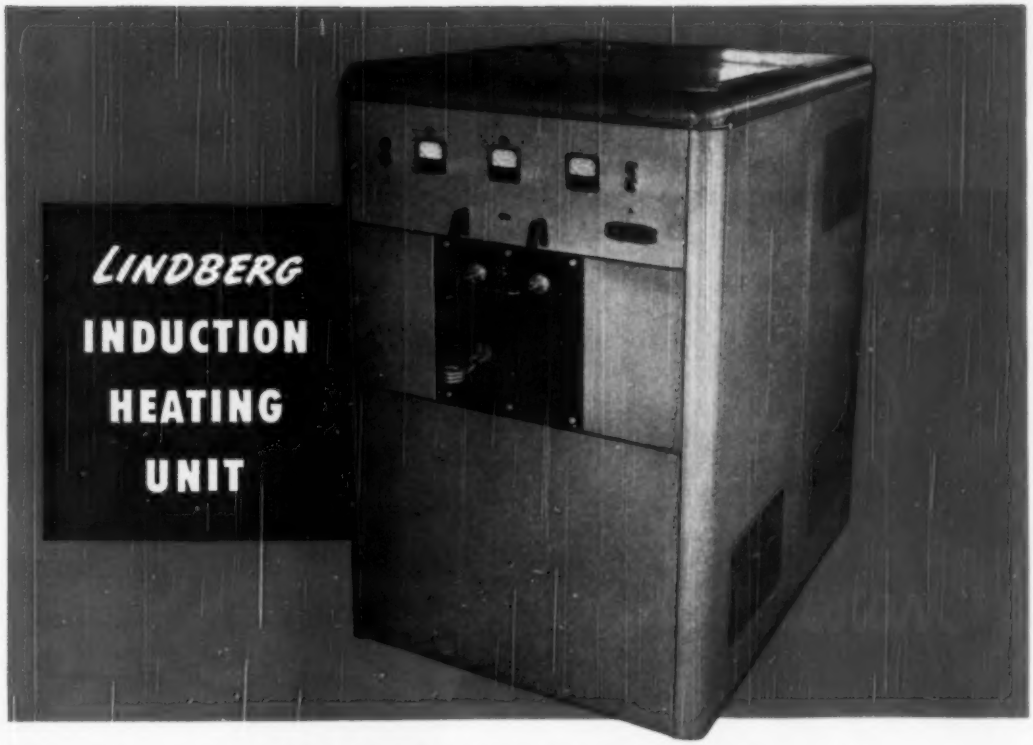
THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices Youngstown 1, Ohio

Export Office 500 Fifth Avenue, New York

COLD FINISHED CARBON AND ALLOY BARS · ELECTROLYTIC TIN PLATE · COKE TIN PLATE · WIRE · PIPE AND TUBULAR PRODUCTS · CONDUIT · RODS · SHEETS · PLATES · BARS · RAILROAD TRACK SPIKES



NEW and EXCLUSIVE developments in induction heating...

Available in single and two-station models the Lindberg LI-25 is ideal for hardening, brazing and soldering, annealing and stress relieving, hot forming and light forging, shrink fitting and other induction heating applications.

The Lindberg LI-25 is a ruggedly constructed vacuum-tube type unit for hard working production line jobs. Oscillator tube, power transformer and other major components deliver a full 25 KW with plenty of reserve to insure dependable day in and day out performance. Well designed—safe and simple to operate—featuring the most desirable developments in high frequency heating.

CONDITIONED COOLING—Built-in to increase tube life, eliminate harmful condensation and scaling, reduce water pressure and consumption—can be used with hard water. Rubber hoses are completely eliminated.

"CHECKLITE"—a unique feature exclusive with this unit, makes servicing easier, reduces maintenance costs.

AUTOMATIC CONTROL—when job cycles are set, automatic timer controls every phase of the operation—heat, quench, fixture movement.

SAFE AND SIMPLE—both operator and operating parts are protected—filament voltages are constantly regulated—tank capacitor is hermetically sealed—work coils protected against burn out. Every unit certified to meet FCC regulations. For detailed information write for Bulletin T-1420.

For specific application information contact your local Lindberg Office, or write describing your problem in detail.

LINDBERG HIGH FREQUENCY HEATING

A DIVISION OF LINDBERG ENGINEERING CO.

2448 West Hubbard Street, Chicago 12, Illinois

IN THE STUDY OF *Grain Growth Characteristics*

Five Hevi Duty Pot Furnaces in the Metallurgy Department at Notre Dame University.

HEVI DUTY
POT FURNACES
Play an Important role

Hevi Duty Pot Furnaces are being used in a great variety of ways throughout industry. Many manufacturers have standardized on these furnaces for production and pilot plants. The Metallurgy Department at the University of Notre Dame is using a battery of five Hevi Duty Furnaces in the study of grain growth characteristics and of recrystallization in high purity aluminum, aluminum base alloys and in high purity and commercial brass. Similar furnaces are used in the study of isothermal transformations in steel.

If your procedure calls for the use of a round or rectangular pot furnace at medium temperature operation, write for Bulletins HD-635 and HD-546. A complete range of sizes is available.

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES **HEVI-DUTY** ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

no second fiddle role today

for stainless sheet and strip

Stainless steel production no longer has to take a back seat. Improved strip mill practices have made it possible to move stainless into the limelight. And as you would expect, CRUCIBLE, the leader in specialty steels, has taken the first step to make stainless as a specialty product by specialty production methods in the *first* mill built *specifically* for stainless. This $18,000,000 mill at the Midland Works was designed and built . . . from the ground up . . . to incorporate the best of accepted techniques, *plus* exclusive features developed by Crucible's industry-famous technicians.

The new mill will roll stainless sheet and strip in widths from ½" to 50" inclusive, in all gauges, grades and finishes. With this new mill in operation, and with Trent Tube Company joining the organization, you can now rely on Crucible for stainless in every form: sheets, plates, strip, bars, tubing, forgings, wire, and castings. When you say, "Give me Crucible", you can rightly expect the best that modern facilities and generations of specialty product leadership can provide. Comprehensive data sheets on request.

CRUCIBLE STEEL COMPANY OF AMERICA
405 Lexington Ave., New York 17, N. Y.
Branches, Warehouses and Distributors in Principal Cities

CRUCIBLE first name in special purpose steels

hot and cold rolled STAINLESS SHEET AND STRIP

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE • STEELS

SUMMARY OF GRAY IRON SPECIFICATIONS

What Properties Do You Want?

CHECK GRAY IRON FIRST!

The Gray Iron "Spec Sheet" of which you see a small portion above, contains a lot of useful data. If you'd like a copy, why not drop us a line?

The wide range of useful properties available in Gray Iron is strikingly apparent from these specifications. Tensile strength, for example, as shown above, can be up to 60,000 psi with good machinability.

Gray Iron offers an unparalleled combination of advantages—unmatched flexibility. That's why the Gray Iron foundry industry is the second largest in the metal-working field. Are you taking full advantage of Gray Iron's possibilities for your products?

Gray Iron Offers These Characteristics:

Castability	Corrosion Resistance
Rigidity	Durability
Low Notch Sensitivity	Vibration Absorption
Wear Resistance	Machinability
Heat Resistance	WIDE STRENGTH RANGE

Make It Better With Gray Iron

Second largest industry in the metal-working field.

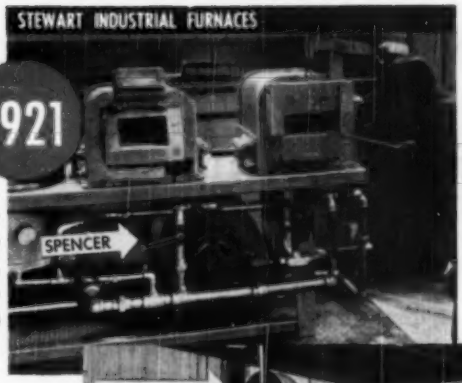
GRAY IRON FOUNDERS' SOCIETY, INC.

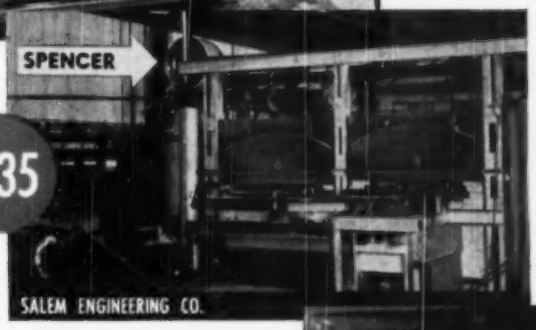
NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

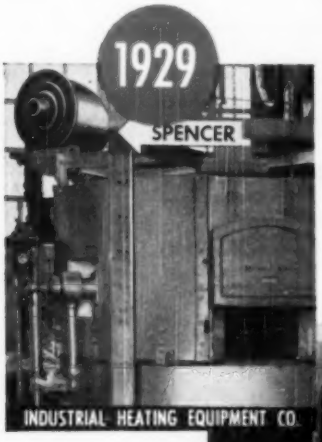
Since 1921

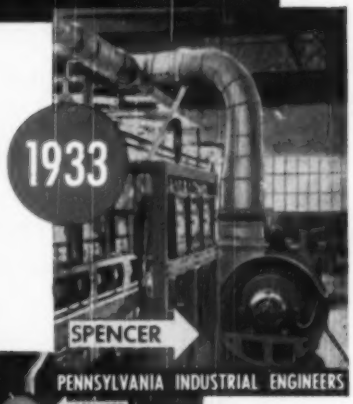
SPENCER TURBO COMPRESSORS

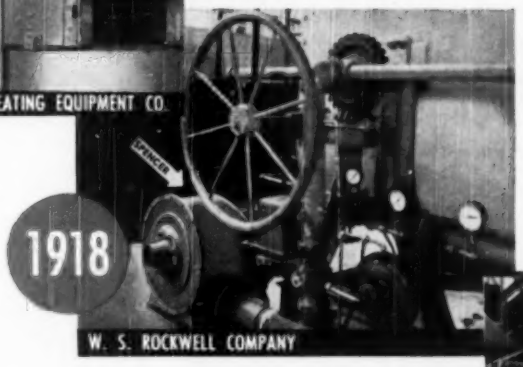
The first Spencer Turbo was installed in 1917. Many of the early machines are still in service. A few of the equipment manufacturers that have used Spencers consistently (see dates) for many years are represented on this page.

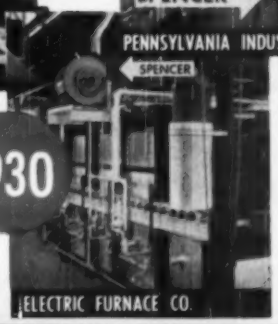












Standard sizes from 35 to 20,000 cu. ft.; ⅓ to 800 H.P.; 8 oz. to 10 lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive consruction available.

Special Spencer Bulletins are available as follows: Data, No. 107, Gas Boosters, No. 109, Four Bearing, No. 110, Blast Gates, No. 122, Foundries, No. 112 and the General Bulletin is No. 126.

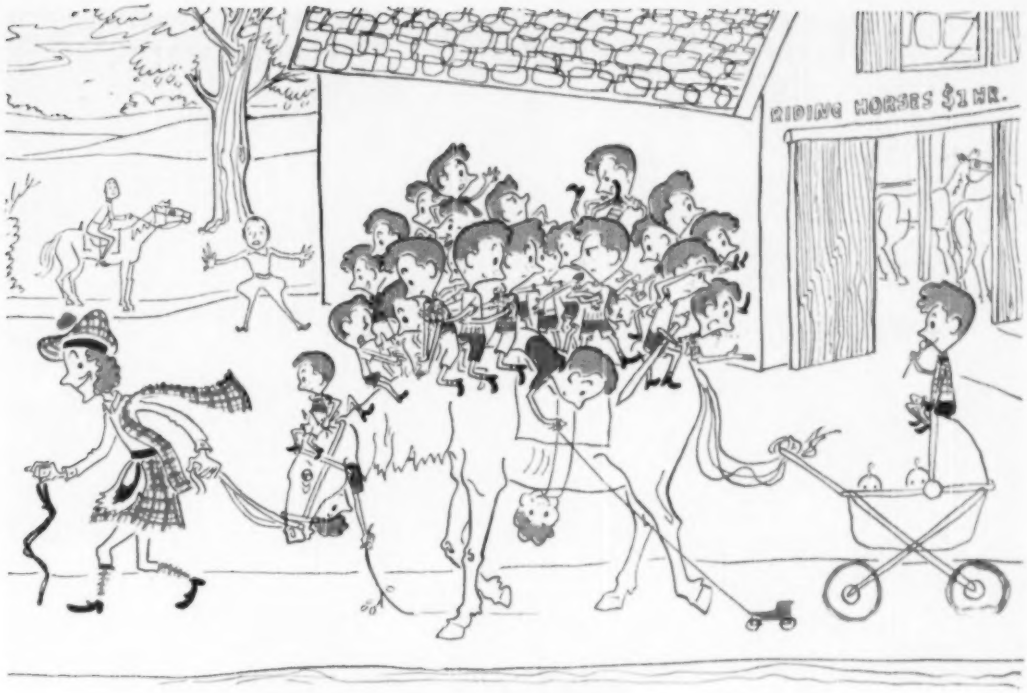
359-B

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

. . Multiple Stage Cleaning is engineered to fit your sequence . .

To meet today's conditions in the plating and metal finishing industry, involving changes in polishing compositions, automatic polishing, heavier and faster production and dirtier work with packed recessed areas, we offer MULTIPLE STAGE CLEANING for proper surface preparation . . . Whether your equipment is manual or automatic, MULTIPLE STAGE CLEANING based on our well-established "Lo-Hi" pH process can be engineered to fit the job . . . in case you are having any cleaning or plating troubles, fill in one of our Engineering Data Sheets, which the NORTHWEST man in your territory can supply you, or write us direct. With this information, which includes your complete sequence, we will make our recommendation.



The Case of the Fabulous Family

When we at the McKay Company stop to think about it—our family of electrodes is indeed fabulous . . . for there are over sixty various types especially designed, developed and manufactured to meet almost every requirement for shielded-arc electrodes.

That's why—if you are weld-fabricating or weld-repairing any or all of the many mild-steels, the alloy-steels or the stainless-steels—you are sure to find a McKay Electrode of the type and size you need. Even if it's a special-purpose electrode for hard-surfacing or other unusual applications, you can be sure that there is a member of the McKay Electrode Family that can do the job and do it well!

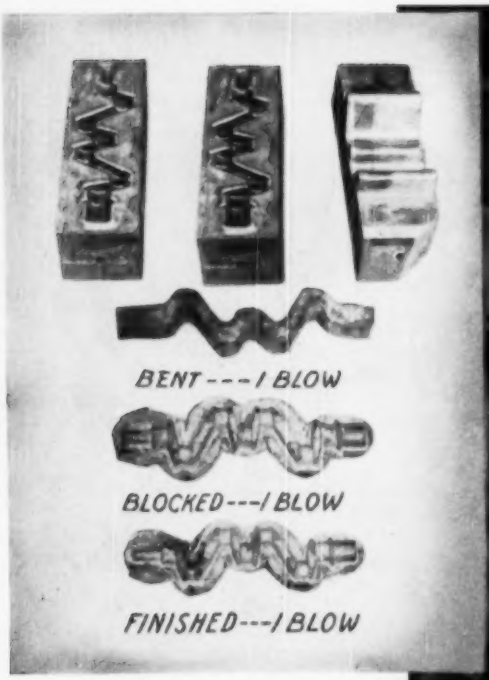
★ ★ ★ ★ ★ ★ ★ ★ ★

If you are undecided as to the correct physical, chemical and metallurgical properties you require, why not contact a McKay Welding Engineer. He'll be happy to help you select the "one" electrode, from the McKay line that does your welding job more economically and better.

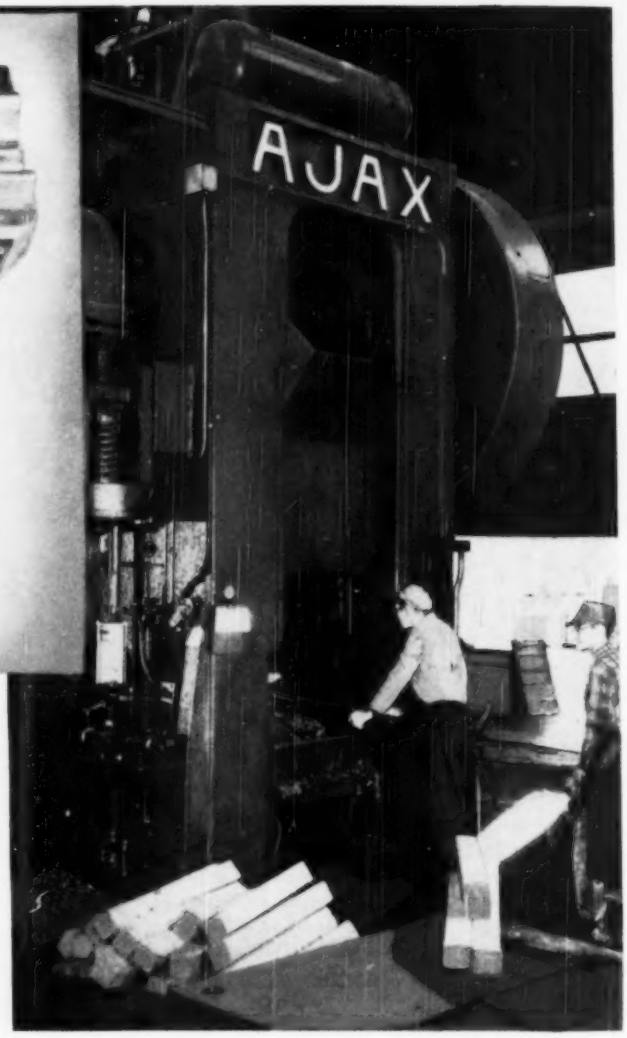
The properties of every McKay Electrode, accurately catalogued, are available on request. Our Technical Service Department welcomes your inquiry.

McKAY STAINLESS STEEL • MILD STEEL • ALLOY STEEL • WELDING ELECTRODES

Researched, Developed and Manufactured to Fit Industry's Requirements for Dependable Electrodes



Dies and Forging Operation for Forging Tractor Crankshaft.



Press Forging Tractor Crankshaft at International Harvester Company, Louisville, Kentucky, Works.

INTERNATIONAL HARVESTER COMPANY

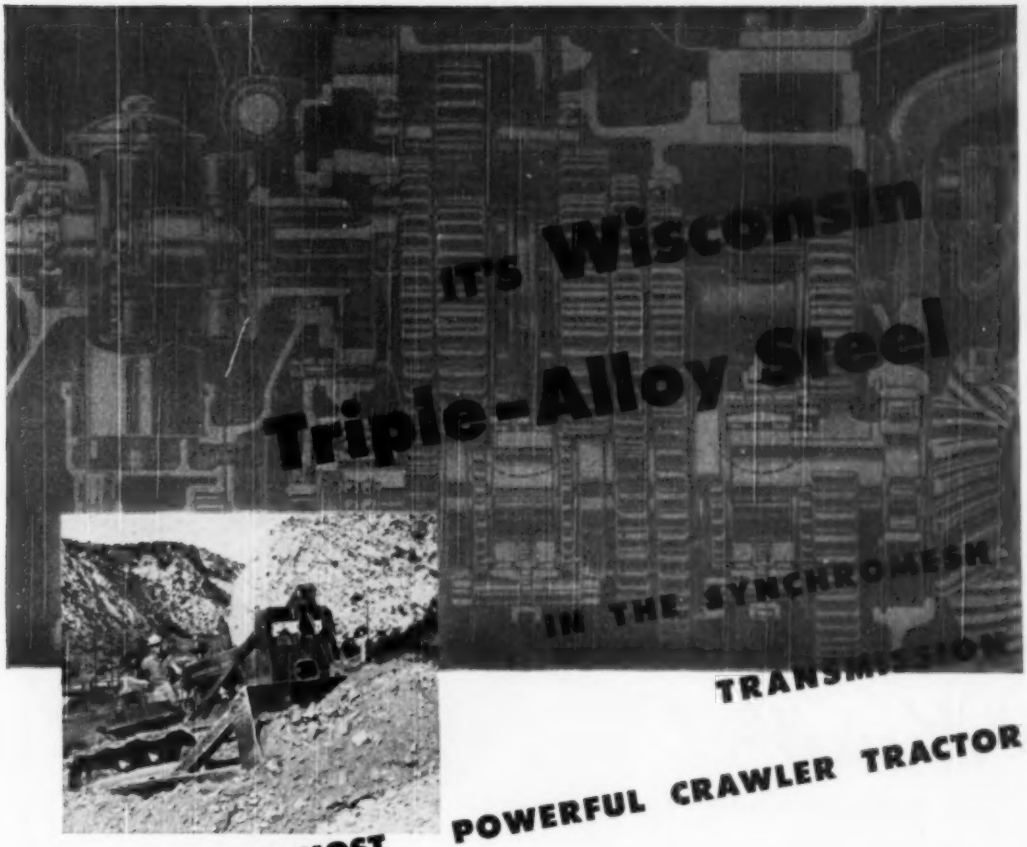
PRESS FORGES TRACTOR CRANKSHAFTS

In the Louisville, Kentucky, works of International Harvester Company, tractor crankshafts as well as axles, steering knuckles and gear blanks are being forged on Ajax High Speed Solid Frame Forging Presses. Ajax Forging Presses afford many production advantages not present in other types of presses, such as solid steel frames without tie rods, greater simplicity of operation, lower maintenance, etc.

The same economies which are effected in press forging tractor parts, apply to an extensive list of parts, in many industries, which can be press forged better, faster and at less cost than by any other known method.

Write for Bulletin 75-B

THE Ajax MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST. CHICAGO 3, ILLINOIS
DEWART BUILDING NEW LONDON, CONN.



Where gears get a beating—in the synchromesh transmission of the International TD-24, the world's most powerful crawler tractor—they're made of Wisconsin triple-alloy steel. And thousands of automotive transmissions are fabricated from this same high quality alloy steel.

Quality counts here. And quality is the watchword at Wisconsin Steel. That's why we invite you to contact our sales and metallurgical staffs when you need steel. Our entire organization is ready to serve you.

WISCONSIN STEEL COMPANY, Affiliate of INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue • Chicago 1, Illinois

WISCONSIN STEEL

This Heat-Treat Idea HIT THE BULL'S-EYE

Here's Why!

EVEN HEATING...NO WARPING...LESS HEAT REQUIRED

Jet Combustion, Inc., Industrial Furnace Builders, had an idea for heat-treating steel rod better and more economically. It involved the use of widely spaced screw conveyors set in troughs—to move the rod through the furnace.

Electro-Alloys engineers worked with them on the design of the conveyors and troughs—using Thermalloy 50-C heat-resistant alloy. The result "hit the bull's-eye".

With this type of furnace, the rod is thoroughly exposed to heat on all sides . . . no "bunching" or uneven exposure can take place. The natural turning action of the rod eliminates sagging or warping.

Once the alloy conveyors and troughs are brought up to temperature, no additional fuel is expended for reheating—as is necessary with pan or slat-type conveyors constantly moving in and out of the furnace. Result!—a worth-while saving in fuel costs.

Here's just one example of how Electro-Alloys design, engineering and production know-how has paid off for one of our customers. It can do the same for you. Why not write us, or contact your nearest Electro-Alloys office, the next time you have a problem involving heat-resistant, abrasion-resistant or corrosion-resistant alloys. Electro-Alloys Division, 1974 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

Specify CHEMALLOY* for corrosion resistance . . . THERMALLOY* for heat and abrasion resistance

WRITE FOR TECHNICAL BOOKLET—Cast 26% CR. 20% Ni Alloys

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

Ve...ations

...AL FINISHING...

METAL STRIPPER — A

An outstanding development for stripping defective electroplated nickel, copper, silver, cadmium and zinc from steel. Fast action . . . no basis metal attack. The highly polished grill cover illustrated has been completely stripped of nickelplate, and is ready for *replating without repolishing.*

EBONOL BLACKENING PROCESSES

Ebonol finishes are used to beautify a widely diversified list of superior quality products. Photo shows steel parts blackened with Ebonol-S and S-30; copper and brass with Ebonol-C; zinc with Ebonol-Z. U. S. Patents — 2,364,993, 2,460,896, 2,460,898.

EMULSION CLEANER — 75

Oils, greases, buffing compounds, solid particles, deep seated in steel parts are cleaned out and completely removed by this emulsification process. Stubborn, gummy substances on die castings, milling machines, floors, motor blocks emulsify and disperse in water instantly.

ENAMEL STRIPPERS

Enthone has over 20 strippers for removing organic finishes — synthetic enamels, lacquers, vinyls, japans. The best strippers, tailor-made for your particular problem, are selected by laboratory technicians after test runs. This service is rendered free of charge.

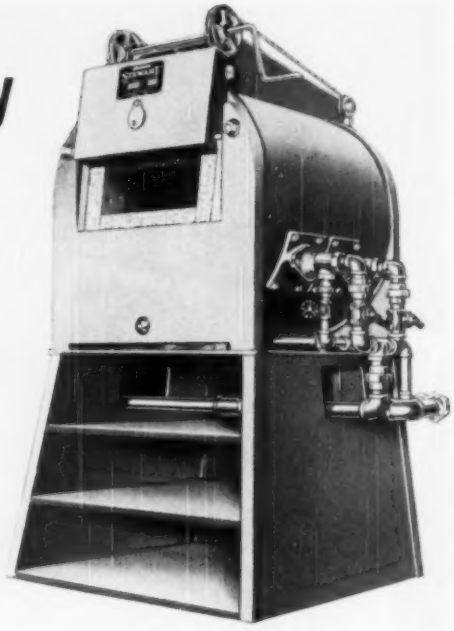
Enthone Incorporated

Now! More Flexibility

Than ever before in a small oven furnace

Sunbeam STEWART

WIDE RANGE OVEN



• 300-2400°F ALL-IN-ONE FURNACE

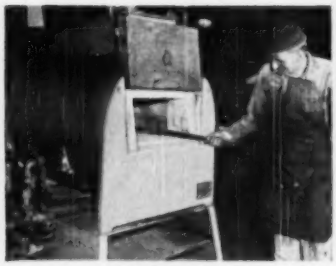
Saves labor time. Get low, high, or in-between heat-treating *all in one unit.* Perfect uniformity. Reaches high heat fast . . . quick return to low, perfectly controlled.

• FULL OR SEMI-MUFFLE OPERATION

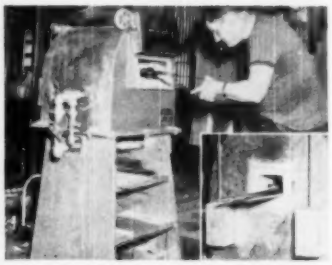
This unit can be converted from semi-muffle to full muffle by means of a silicon carbide top section. Thus atmosphere controlled hardening as well as normal heat treating can be done.

IDEAL FOR SHOP OR PLANT USE...

AT ROYAL TYPEWRITER, INC., *Hartford, Connecticut, seven Wide Range Ovens are in use. Four are used on a 16-hr. daily schedule; the other three intermittently for tool and high speed hardening.*



AT CARNEGIE-ILLINOIS STEEL CORPORATION, *Gary Sheet Mill, general forging and forming, cleaning, etc., are carried out at 1800°-2400°F. For shrinking operation, temperatures as low as 300°F may be used.*



AT ALUMINUM COMPANY OF AMERICA, *Chicago works, this oven is used for miscellaneous tool work. Material heat treated includes tool and dies of small sizes, shapes and weights. Special removable plug permits center heating of long bars.*

Combustion chamber design plus location of special nozzle-mixing burners and 95% turn down ratio on this Wide Range Oven gives *tremendous* turbulence to the combustion gases. This assures close temperature control and even heat distribution—making the unit practical for a multitude of metal heating processes. The furnace is adaptable to two-valve manual control or automatic temperature control, employing an air/gas proportioning valve.

MAIL TODAY FOR COMPLETE INFORMATION

Attach to company letterhead, or write on company stationery.

SUNBEAM STEWART INDUSTRIAL DIV., 4433 Ogden Ave., Chicago 23

Heating Space: ☐ 4"x8"x12" ☐ 6"x12"x18" ☐ 9"x15"x24"

(Name) (Position)

(Firm)

(Address)

Sunbeam STEWART **INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION**

(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 108, 4433 Ogden Ave., Chicago 23 — *New York Office:* 322 W. 48th St., New York 19 — *Detroit Office:* 3049 E. Grand Blvd., Detroit

Canada Factory: 321 Weston Rd., So., Toronto 9

for economy in coiling,
knotting, forming —

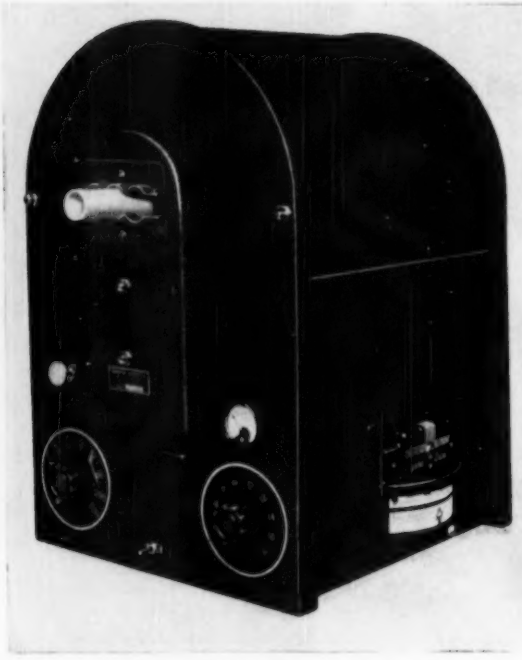
use **Pittsburgh**
SPRING WIRE

You, like many others will find that Pittsburgh Spring Wire gives you economy in your operations that looks good on your cost sheets. The close control of chemistry, the precision wire drawing at Pittsburgh Steel gives you a wire that is best suited for your coiling, knotting, forming and twisting operations. It has uniformly high tensile strength and the stiffness to give you the best finished spring. Its size accuracy and ductility make it easy to work in your machines. Available in upholstery grade as well as M. B. Specify Pittsburgh Steel Spring Wire for all your production. For information write Department MP, Grant Building, Pittsburgh 30, Pa.

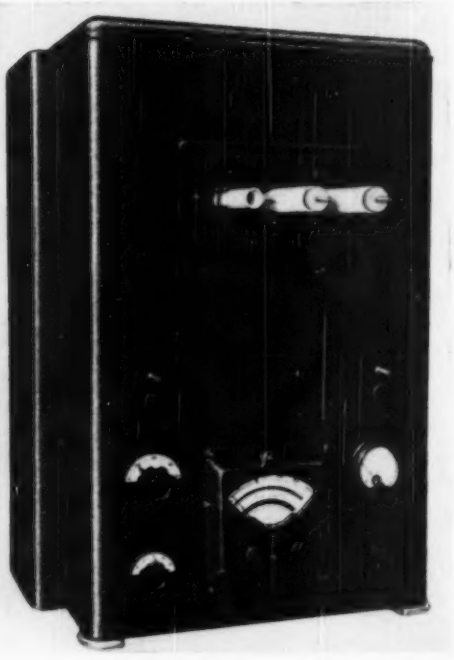
Pittsburgh Wire

A product of **PITTSBURGH STEEL COMPANY**

Heating is Fast..Versatile..Dependable with GLOBAR Heating Elements



● "Varitemp" Combustion Furnace operates as single or double tube furnace.



● "Hitemp" Combustion Furnace operates as single, double or triple tube furnace.

Both furnaces illustrated are made by Harry W. Dietert Company, 9330 Roselawn Ave., Detroit, Michigan.

Combustion furnaces equipped with GLOBAR silicon carbide heating elements facilitate rapid—yet accurate determination of carbon and sulphur in organic and inorganic materials. Installed around combustion tubes in which samples are tested, these elements respond rapidly to thermal control requirements through an extremely wide range. Complete combustion of even the more heat resistant alloys is assured. Dependable operation over extended periods of time is obtained.

Dietert "Varitemp" and "Hitemp" Combustion Furnaces Make Effective Use of GLOBAR Heating Elements

GLOBAR non-metallic heating elements make these completely packaged furnaces easy to operate and maintain. Combustion tube temperatures are controlled quickly and conveniently. Installation of new elements is readily accomplished without cooling the furnace. Clean, quiet, uninterrupted performance is provided.

For complete information on installation and operating details of GLOBAR heating elements, write Dept. X-30, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

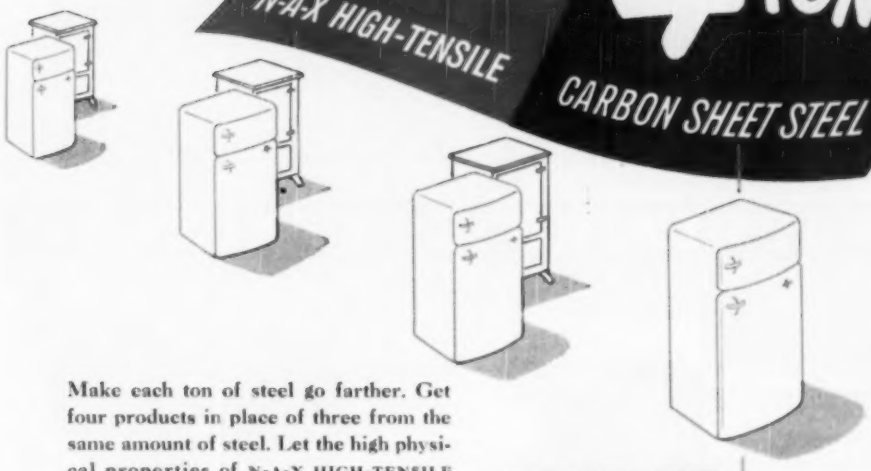
GLOBAR Heating Elements BY CARBORUNDUM TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

the New Arithmetic in Steel

3 TONS > 4 TONS

N-A-X HIGH-TENSILE CARBON SHEET STEEL



Make each ton of steel go farther. Get four products in place of three from the same amount of steel. Let the high physical properties of N-A-X HIGH-TENSILE take the place of mass in your product design to boost production per ton as much as 33%. This new efficiency in the use of steel is part of industry's constant search for better materials.

With N-A-X HIGH-TENSILE steel you are assured of high resistance to distortion, impact fatigue and corrosion. Yet you are also assured of excellent cold formability and weldability.

Thus you can redesign many steel products with sections 25% thinner—to save weight, save steel. And further savings in fabricating and finishing pay the way to use of this better, more efficient material.

Let us talk over with you the application of N-A-X HIGH-TENSILE to your product. We believe we can show you how to increase production per ton as much as 33%.

N-A-X HIGH-TENSILE STEEL

GOES FARTHER

Builds More Products per Ton

MAKE A TON OF SHEET STEEL GO FARTHER Specify— N-A-X HIGH-TENSILE STEEL

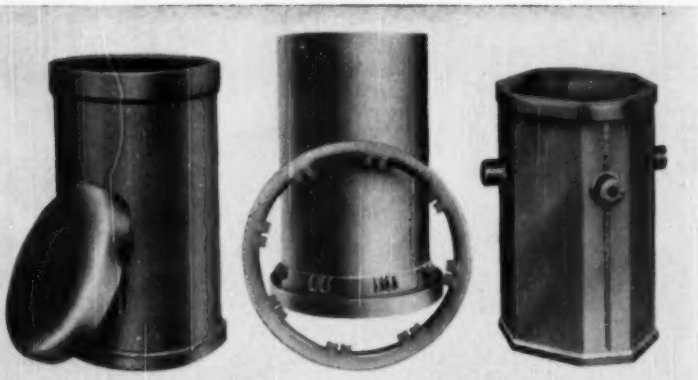
GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • ECORSE, DETROIT 29, MICHIGAN • UNIT OF NATIONAL STEEL CORPORATION

The PRESSED STEEL CO.

PSC

Light-Weight



The original PSC carburizing box, now the most widely used in industry.

Welded alloy retort for gas carburizing furnaces. Serving 10,000 hours.

An example of the many special-purpose boxes we design and fabricate.

CARBURIZING CONTAINERS

for Every Purpose

It is probably enough to cite one reason why 80% of the nation's heat treaters today use PSC carburizing boxes: -- *They Cut Production Costs.*

Weighing 2/3 less than cast boxes, they handle easier and faster and thus increase productivity per employee. Obviously, because of their lighter weight PSC containers require less time to attain pot heat, and thus cut fuel costs. Furthermore, plant records show PSC units last 2 to 20 times longer. PSC units are furnished in any size, design or metal specification, and for every purpose: annealing and carburizing boxes, baskets, racks, tubes, retorts, etc. Send blue prints or write as to your needs.

Right above— these chimney type boxes for carburizing ring gears are made in any size.

Right below— PSC boxes that are light weight for easy handling, yet will not warp.

Special PSC retorts for small lots of different parts in battery of gas furnaces.

Low-Cost Short Cut to More Efficiency

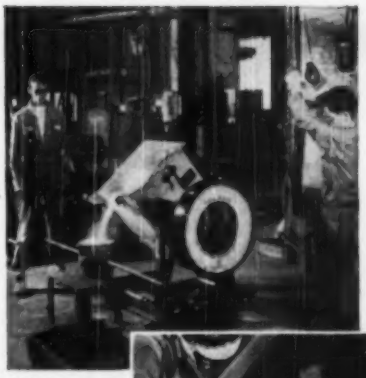
THE PRESSED STEEL COMPANY

of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

FOR *Precision Casting*



Melting alloy iron for centrifugal casting at Koppers Company, Piston Ring Division

Pouring super-alloy from 300 lb. Ajax-Northrup furnace at Mercast Corporation

Precision investment castings being made by Arwood Precision Casting Corporation

USE AJAX-NORTHRUP MELTING

For all precision casting—centrifugal casting, lost-wax processes, the Mercast process, etc. — one furnace alone is outstanding for perfect control over production melts of tough-to-handle alloys—with low maintenance year after year. That is the Ajax-Northrup high frequency furnace. Thousands of these furnaces have successfully handled all types of alloys over a period of 33 years.

FAST—it melts 5 lbs. of steel in 13 min. with self-tuning 20 kw. Ajax-Northrup converter, or 100 lbs. in 20 min. with 100 kw. motor-generator. So fast there's no chance for oxidation.

CLOSE ANALYSES — LOW CARBON — good for stainless steels where carbon should be held below 0.08%. Carbon can be controlled within 0.01 or 0.02%; other alloying elements within 0.25%. It's the most economical way to melt metals high in chromium, nickel, tungsten, cobalt, selenium, etc.

ECONOMICAL — generally more efficient than other electric furnaces of same size. "Pays for itself by saving alloying constituents and deoxidizers," says one user. And on alloy cast iron, Ajax-Northrup melting plus centrifugal casting doubled the yield of finished castings per ton melted.

CAPACITIES—from 8 oz. to 50 lbs. with trouble-free spark gap converters, and from 10 lbs. to several tons with motor-generator operated units. Linings and crucibles to suit all alloys. Easily interchangeable for handling different alloys. Write for more facts.

118

SINCE 1916

AJAX ELECTROTHERMIC CORPORATION

AJAX PARK, TRENTON 5, N. J.

Associate Companies

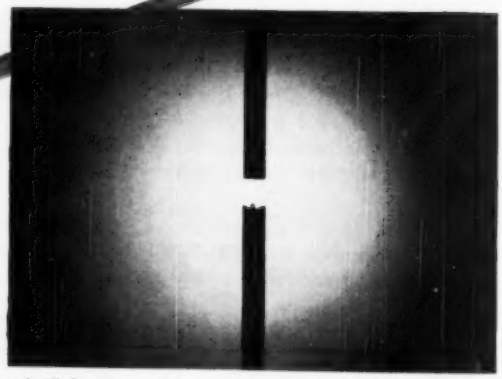
THE AJAX METAL COMPANY • AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC. • AJAX ENGINEERING CORPORATION

AJAX NORTHRUP
HEATING & MELTING

The AMERICAN DIE CASTING INSTITUTE

is to be congratulated for providing industry with a metallurgical yardstick in the form of a voluntary control system based on spectrography which assures consumers of the purity and hence, the superior physical properties inherent in die castings made of 99.99+% zinc. With such assurance manufacturers can make still greater use of the products of this comparatively young and vigorous industry whose phenomenal growth in recent years has made it the second largest consumer of zinc.

ST. JOSEPH LEAD COMPANY
250 Park Avenue • New York 17, N. Y.



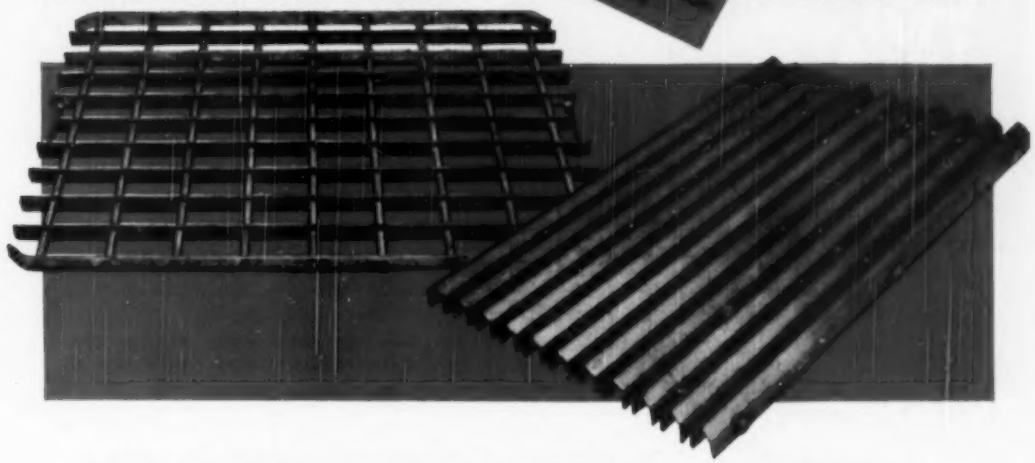
A spectrograph is basically a picture of a spark. All elements, when "excited" by heat or electrical discharge, emit radiations of known wave lengths. In spectrography, this light is dispersed into its component parts (the spectrum) and recorded on a photographic plate. The wave lengths are always the same regardless of what other elements are present in the substance under investigation, and since these wave lengths are accurately known it is possible to identify each line in the spectrum and thus gain a complete knowledge of the composition of the metal. The density of the spectral line bears a direct relation to the amount of the element present, therefore the spectrograph also provides a basis for quantitative analyses.

BUNKER HILL 99.99+% ZINC

ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT



ARTICULATED TRAYS *for highest resistance*

to WARPING . . . UNDER EXTREME TEMPERATURES

The two trays shown above are now in use for copper brazing parts in Roller Hearth Furnaces at 2050° F. The carefully checked performance of each shows the importance of job-engineered design for a specific condition.

Flat bar construction of the 60 lb. tray (at left) with bent outer bars, to avoid catching on roll guides, gives optimum performance with loads 100 lbs. and over. Hot rolled bars prevent scoring of furnace rolls . . . flexible construction eliminates warping and cracking. Handles at ends also serve to index cover-screen for small parts.

For loads *under* 75 lbs. the channel type design (right) proves more economical. This tray weighs 37 lbs., handles loads to 70 lbs. The light weight sheet metal channels with two-way pipe spacers are most flexible for prevention of warpage . . . and assist in maintaining high furnace capacities.

If you are experiencing tray troubles . . . short service life, cracking, warping . . . ask Rolock engineers for recommendations. We can cut your heat-hour costs and improve product processing. Catalog and Bulletins on request.

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

5RL50

THE FASTEST MACHINING STEEL EVER PRODUCED!

LA-LED

NEW, LEAD-BEARING OPEN-HEARTH STEEL MACHINES *TWICE* AS FAST AS B-1112

LA-LED ALSO HAS THESE IMPORTANT QUALITIES

- IMPROVED FINISH
- SOUNDER CROSS SECTION
- BETTER CARBURIZATION
- BETTER BENDING, CRIMPING, RIVETING, PROPERTIES
- CLOSER MACHINED TOLERANCES

Because machinability is such an important factor in finished part cost, new LA-LED is causing a sensation among users of free-machining screw stocks! Production runs on thousands of tons of LA-LED have resulted in increased production over B-1113 of 45% to 106%!

But LA-LED has more than super-machinability. Being an open-hearth steel, it will carburize better and have a much sounder cross section than Bessemer. Furthermore, it has inherent good ductility and surface quality, which permit bending, crimping, and riveting operations impracticable with Bessemer steels. It machines to a fine satiny finish and permits closer finished part tolerances. LA-LED is available cold finished, in rounds, 5/16" thru 3"; and in hexagons, 5/16" thru 1½".

HERE'S PROOF

WASHER INSERT

LA-LED replacing B-1112; machined from ⅝" round on Greenlee Automatic

Form Tool	R.P.M.	+152%
Form Tool	S.F.M.	+130%
Form Tool	Feed	Unchanged
Drill	S.F.M.	+137%
Drill	Feed	Unchanged
Tapping	S.F.M.	+150%
Time/Part	Seconds	—39%
Production	Per Hour	+63%
Steel Cost		+16%

GEAR BLANK

LA-LED replacing B-1113; machined from 2¼" round on Acme-Gridley

Form Tool	R.P.M.	+41%
Form Tool	S.F.M.	+42%
Form Tool	Feed	+31%
Drill	S.F.M.	+40%
Drill	Feed	+76%
Time/Part	Seconds	—40%
Production	Per Hour	+67%
Steel Cost		+13%

WRITE FOR DESCRIPTIVE PAMPHLET

LaSalle Steel Co.
1424 150th Street, Hammond, Indiana

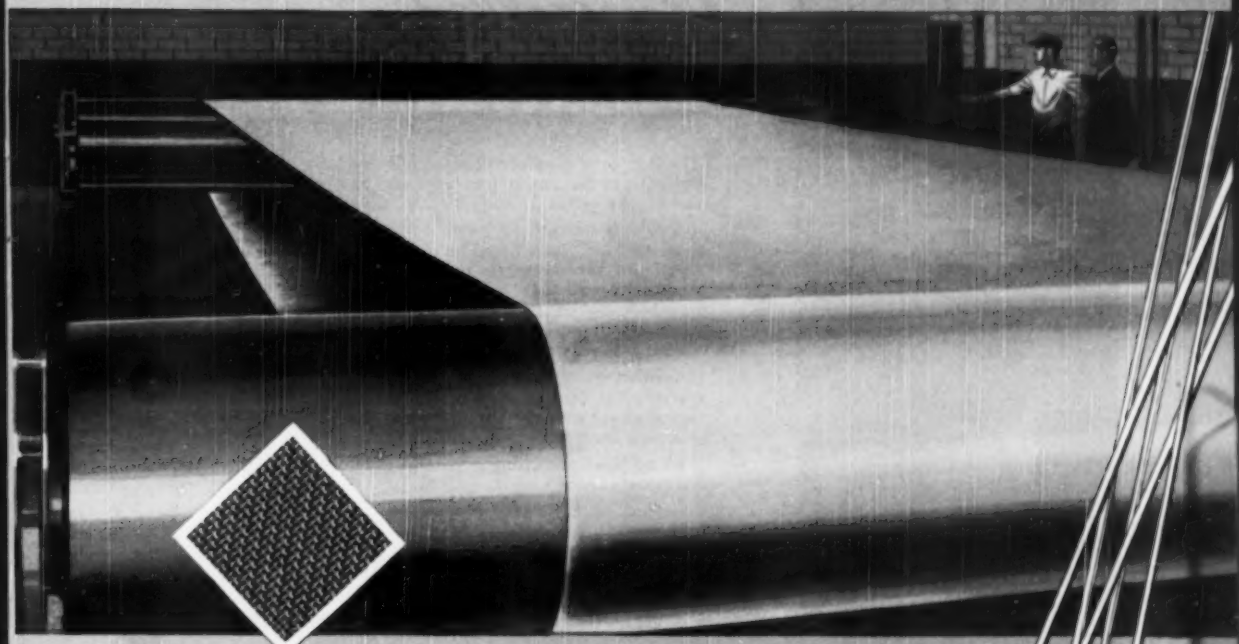
Please give me more information on how LA-LED can increase production and cut the cost of screw machine parts in my shop.

Name _____
Title _____
Company _____
Address _____
City _____ State _____

LaSalle STEEL COMPANY

Manufacturers of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Bars in America

RIVERSIDE TAUGHT THIS WIRE TO STRETCH ITSELF AND CARRY TONS OF CORROSIVE PULP



Wire almost as fine as human hair forms the Fourdrinier screens that carry pulp in paper manufacture.

Manufacturers of this wire, from which the screens are woven, had a great deal of trouble at one time because the stock supplied to them for drawing varied widely in composition and properties. The eventual result was breakage in the loom, excessive wear and lowered resistance to abrasion in service.

So they came to Riverside.

Riverside tackled the job, developed a phosphor bronze alloy to meet requirements. This particular alloy is notoriously difficult to make but Riverside found a way to control uniformity within very narrow limits. Result:—No premature breakage of the wires in weaving, negligible effects from abrasion and fatigue, and maximum resistance to abrasion.

This same meticulous analysis and processing can help you with your *Phosphor Bronze, Nickel Silver, Cupro Nickel* and *Beryllium Copper* problems. In cooperation with your technicians, Riverside specialists will review specifications and fabricating methods; test chemical, physical and metallurgical properties; examine the entire case history of your product; *recommend a specific solution*. And finally, we'll produce your alloy—standard or special—from raw materials to finished stock, and warrant it to meet your specifications.

If there's an alloy puzzle on your desk—or around next week's corner—send the case history to us. Meanwhile, be sure to ask for our new pocket-size Alloy Handbook. It's a mine of non-ferrous alloy information, and it's yours for the asking.

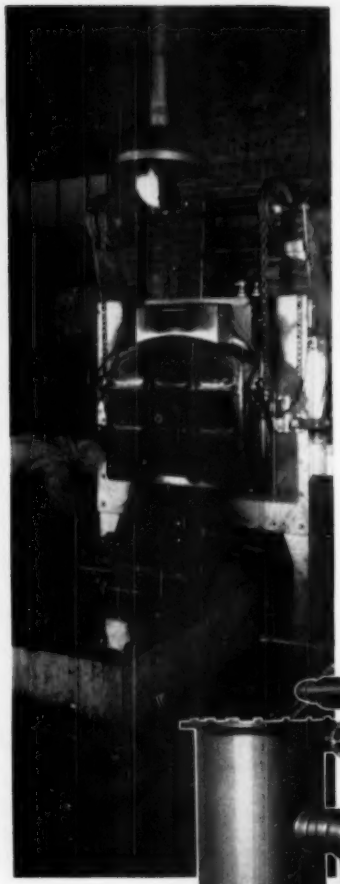
RIVERSIDE ALLOYS

Alloys built by research, proved by use

phosphor bronze • nickel silver • cupro nickel • beryllium copper

THE RIVERSIDE METAL COMPANY
Riverside, New Jersey
Newark, N. J. • Cleveland, Ohio • Chicago, Ill.
Hartford, Conn. • Rochester, N.Y. • Detroit, Mich.

Export Agent: International Brass & Copper Co., Inc., 80 Broadway, New York City



Controlled QUENCHING PRESERVES THE *QUALITY!*

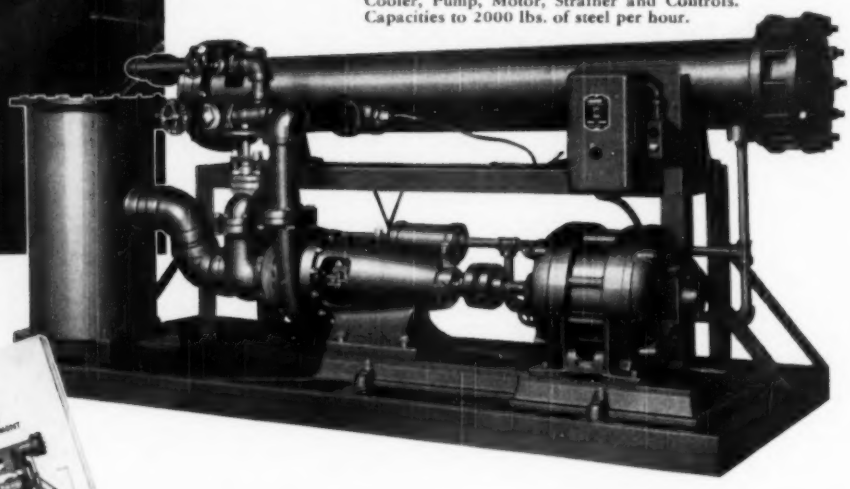
The degree of control exercised in quenching heat-treated metal determines the amount of time and materials wasted by sub-standard rejects . . . *and ultimate operating costs!*

You can be sure of better results if you rely on a B & G *Hydro-Flo* Oil Quencher. The temperature desired in the quench bath will be accurately maintained throughout the quench period. The oil will be strongly agitated to avoid formation of gas bubbles which cause irregular surface hardness. Your product will emerge *uniform in quality*—every time!

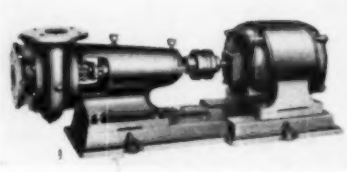
While B & G *Hydro-Flo* Oil Cooling equipment can be purchased in separate units for assembly on the job, many heat-treaters are buying B & G Self-Contained Coolers. The advantages are obvious—all parts are factory-assembled into one complete unit, ready for immediate installation.

Bring your quenching problems to the B & G engineering department—there's no obligation in discussing them.

B & G Series "OC" *Hydro-Flo* Oil Cooler
Completely self-contained—equipped with Cooler, Pump, Motor, Strainer and Controls. Capacities to 2000 lbs. of steel per hour.



Send for this combined Catalog and Simplified Selection Manual.



A complete line of flexible and close-coupled centrifugal pumps. Send for engineering data.

Hydro-Flo OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY
Dept. BK-16, Morton Grove, Illinois

Heat-treating equipment since 1916

*Reg. U. S. Pat. Off.

How do these pieces fit together in your forging picture?

CHANCES are good that your particular cost-quality puzzle can be solved with Timken® forging bars. Uniformity is the key.

Finished products made from Timken forging bars have uniformly high quality because you start with uniformly high quality stock. Superior surface and internal quality is a feature of every bar.

And costs are lowered through fewer delays, fewer rejects and fewer changes in shop practices—results of Timken forging bars' uniform forgeability, uniform response to heat treatment and uniform physical and chemical properties.

This uniformity is maintained by The Timken Roller Bearing Company's close, complete quality control. Every step of manufacture is under the Timken Company's roof. And special mill practices, advanced research, special inspection techniques and years of experience all help keep the quality of Timken fine alloy forging steels the best.

For qualified help with your forging problems, write us today. Ask, too, for our authoritative, 112-page booklet, "Evaluating the Forgeability of Steels". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO"

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing

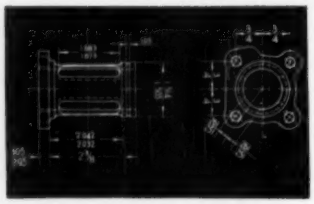
MISCO *Precision* CASTINGS

CARBON AND STAINLESS STEEL

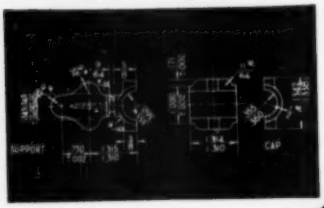
CAST TO MICROMETER TOLERANCES

Precision Casting Provides LOW-COST PRODUCTION of small, intricate steel parts

Part:
AIRCRAFT CARBURETOR METERING VALVE
Alloy: Misco 18-8 (A.M.S. 5640)
Weight: 7.6 oz.



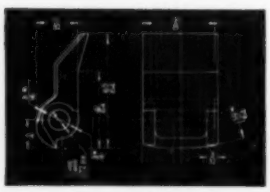
The part produced to highest aircraft material specifications represents a saving of 84% waste material which would result if machined from solid bar stock.



Part:
BRACKET SUPPORT AND CAP (AIRCRAFT)
Alloy: Miscrome 1
Weight: 5.2 oz.
(A.I.S.I. Type 420 Nominal)

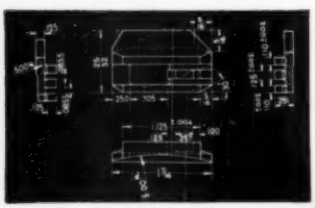
Both parts of this actuator assembly are precision-cast to close tolerances. The use of this process eliminated forging die expenses, and resulted in great reduction of machining cost.

Part:
CORE CATCHER FINGER
(Oil well drilling equipment)
Alloy: Miscrome 4 (A.I.S.I. Type 410 Modified)
Weight: .6 oz.



Over 100,000 castings have been produced to the most exacting physical and metallurgical specifications. The exceedingly high service stresses require critical inspection including 100% X-ray.

The Misco Precision Casting Process offers industry a tested and improved way of producing hard-to-machine parts in highly alloyed stainless as well as in carbon and low alloy steels. The process permits large-quantity production of very accurate, highly finished castings which compare favorably in soundness, perfection of surface and dimensional accuracy with parts made by costly machining methods. Complex shapes can be reproduced in minute detail to tolerances of ±.004″ per linear inch of length, width, diameter or thickness. Finishing operations are reduced and in most cases eliminated. Tooling cost is low and production can be scheduled for early delivery. We will gladly assist you with your design, material and production details. Your inquiries will receive quick attention.



Part:
SEWING MACHINE FEED DOG
Alloy: Miscrome 1 Weight: .6 oz. (A.I.S.I. Type 420 Nominal)

Replacing a part formerly produced from solid stock the precision casting eliminates costly machining operations.

SEND FOR THIS BOOKLET *Provides you with valuable and essential precision casting data*

The striking qualities of the Misco Precision Casting Process are fully described in our 20-page booklet. Compiled to present the latest development in precision-casting to those requiring small, accurate, steel parts in large quantity. Write for your copy now.

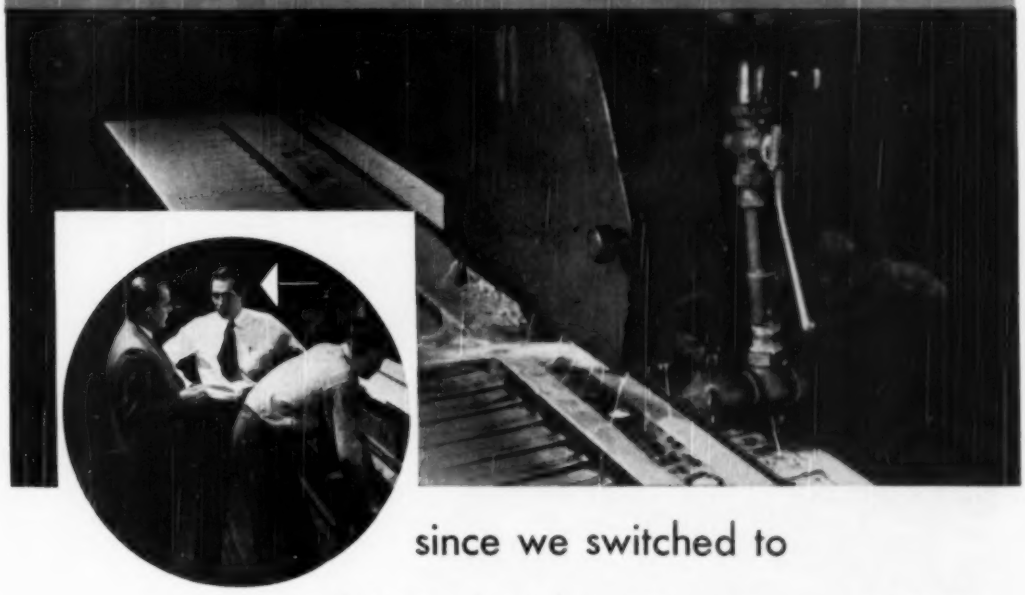
PRECISION CASTING DIVISION
Michigan Steel Casting Company

MISCO
Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys

1998 GUOIN STREET • DETROIT 7, MICHIGAN

"No more rancidity, No more wheel loading troubles



since we switched to

Gulf Soluble Cutting Oil,"

says this machine shop Foreman

"With each of the soluble oils we used previously, we had a serious problem in the operation of this grinder," says this machine shop Foreman. "The emulsion became rancid so quickly that we had to clean the circulating system and replace the entire charge frequently."

"Although the situation is aggravated by intermittent operation—the emulsion stands idle for long periods of time—we have been able to eliminate this problem entirely by simply switching to Gulf Soluble Cutting Oil. Then too, we have noticed that our grinding wheels cut cleaner with Gulf Soluble Cutting Oil—they don't load up nearly so fast."

Experiences like this with Gulf Soluble Cutting Oil make it the preferred cutting fluid in scores of machine shops. Here are a few of the reasons why it does such an outstanding job: It emulsifies readily with all but the hardest water, forms a stable emulsion, and contains an effective rust inhibitor.

For further information on Gulf Soluble Cutting Oil —and for one of Gulf's practical slide-rule-type calculators which will help you maintain desirable soluble oil concentrations—send the coupon below.

GULF OIL CORPORATION · GULF REFINING COMPANY

GULF BUILDING, PITTSBURGH, PA.

Sales Offices - Warehouses

Located in principal cities and towns throughout Gulf's marketing territory

GULF INDUSTRIAL LUBRICATION

Gulf Oil Corporation · Gulf Refining Company MP
3800 Gulf Building, Pittsburgh 30, Pa.

Please send me, without obligation, the material I have indicated below:

- ☐ Further information on the new Gulf Soluble Cutting Oil.
- ☐ Practical slide-rule-type calculator for help in maintaining desired soluble oil concentrations.

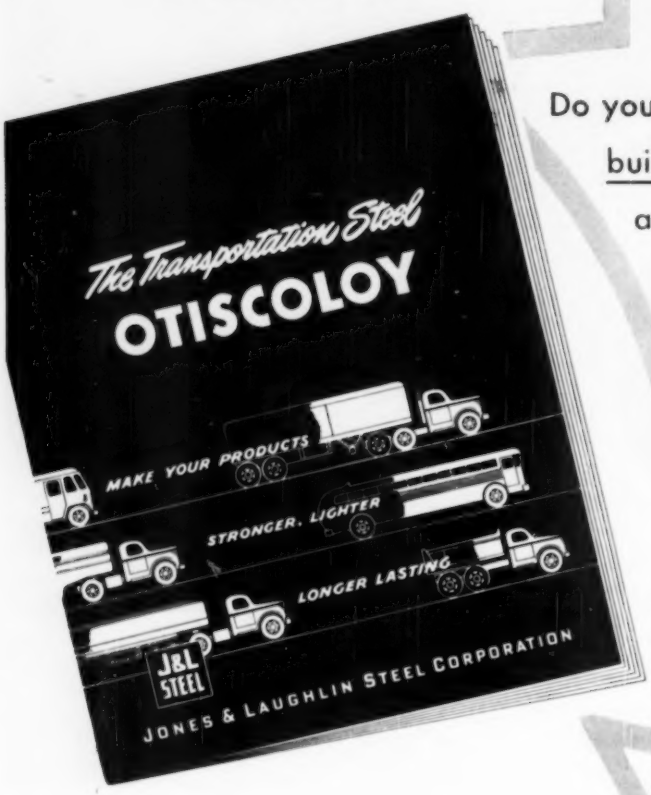
Name .....

Company .....

Title .....

Address .....

You can get this book FREE



J&L STEEL

Do you design, build or use any of these?

- TRUCKS
- BUSES
- ROAD MACHINERY
- RAILROAD CARS
- FARM MACHINERY
- SHIPS
- POWER SHOVELS
- CRANES
- MINING EQUIPMENT

Then mail this Coupon **TODAY**

This Free 32-page illustrated book may be worth a lot of money to you. It tells how you can fabricate *Otiscoloy* . . . how you can use it . . . gives you mechanical properties . . . and information on its high resistance to corrosion, abrasion and fatigue.

Structures of all kinds can be made *lighter—stronger—longer lasting* with "The Transportation Steel"—OTISCOLOY. Don't delay in learning how to put this high-tensile steel to work for you. The coupon is for your convenience.

JONES & LAUGHLIN STEEL CORPORATION

From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY *(hi-tensile steels).*

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

JONES & LAUGHLIN STEEL CORPORATION
405 Jones & Laughlin Building
Pittsburgh 30, Pa.

☐ Send me a free copy of "The Transportation Steel."
☐ Please have your salesman call, without obligation.

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

_____

COMPARE IT WITH ANY OTHER COPPER PROCESS

...and you'll specify Unichrome Copper every time!

WHAT'S YOUR MOST urgent problem in copper plating today? If it's a question of supply, or getting your work through faster, or plating with greater economy—then Unichrome Copper is the all-purpose process for you!

One plater, for example, reports a 70% saving in copper buffing time on zinc die castings. Another, finishing steel parts, finds that Unichrome Copper requires fewer man-hours than any other process he has ever tried. And with hundreds of other platers it's the same story—better results, in less time, for less money. That's why we say: compare it with any other process—and we believe you'll specify Unichrome Copper every time!

BUFFING TIME IS CUT—often eliminated entirely—because Unichrome Copper gives you a *smoother* deposit. And because it's a *fast* process, you save time in the tank as well. Only when you save *both* ways do you really lower plating costs.

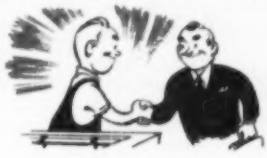
FEWER ANODES required, because the bath keeps them free of oxides even at high current densities. Why tie up extra money when Unichrome Copper has 100% anode efficiency—with 50% to 75% fewer anodes?

SEND FOR THIS HELPFUL BULLETIN

It gives you a plating time-table, technical data, and much of the detailed information you need to do a good plating job. And a Unichrome engineer will be glad to offer you further help on any specific plating problem. There's no obligation—simply write your nearest Unichrome office.

NO CYANIDE is used in the Unichrome Copper bath—so you not only reduce your stocks of this hazardous chemical, but get a safer bath as well.

CLEAN DEPOSITS never need activation. With no brighteners, no wetting agents used, Unichrome deposits come out clean, ready for the nickel cycle without special treatment.



HELPFUL SERVICE—Unichrome Copper is simple to maintain, seldom gives trouble. But should the need arise, you can always count on prompt help from our engineers and analytical laboratories.

UNICHROME

PROCESSES AND MATERIALS FOR SURFACES THAT SURVIVE

Chromium Plating • Porous Chromium • Unichrome* Copper
Unichrome Lacquers • Ucilon* Protective Coatings
Unichrome Stop-Off Lacquers and Compounds • Unichrome Dips
Unichrome Rack Coatings • Anosinc* Compounds • Unichrome Strip
*Trade Mark

UNITED CHROMIUM, INCORPORATED

51 East 42nd St., New York 17, N. Y. • Detroit 20, Mich. • Waterbury 90, Conn. • Chicago 4, Ill. • Los Angeles 11, Cal.

Wheelco electronic instruments give you an electronic brain — an instru*mentality* which responds at the speed of light to help make your present production or process equipment more valuable — more efficient!

The instru*mentality* of the Wheelco Capacitrol gives you instantaneous indication and automatic control over power, voltage, current, speed and other electrically measurable factors.

Assure fewer rejects and greater product uniformity through a closer, uninterrupted control of temperatures.

Assure fuel economy through the instant response to the slightest temperature change.

Remember, instru*mentality*, whether used in the Capacitrol or other Wheelco instruments gives you benefits through simplified supervision and ease of maintenance and service.

When specifying instruments, specify Wheelco — get the electronic link, the instru*mentality* for efficiency and economy.

Surface-mount Limitrol

Portable Pyrometer

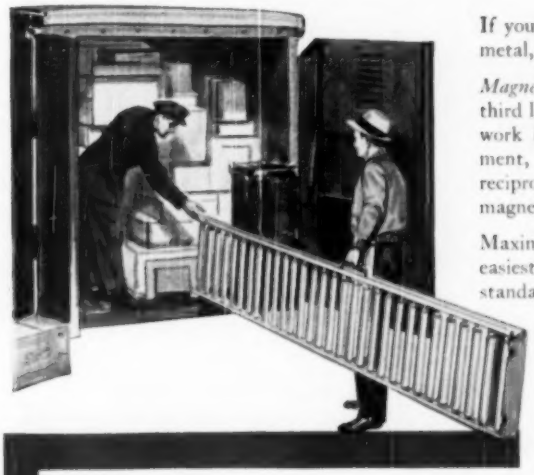
Write for Bulletin Z-6500,
Wheelco Instruments Company,
835 W. Harrison Street, Chicago 7, Illinois

wheelco *electronic controls*

Greater ease in use accompanies products made lighter with Dow

MAGNESIUM

the world's lightest structural metal!



If you are looking for a way to improve your product, one metal, Magnesium, deserves your first consideration.

Magnesium is the world's lightest structural metal—a full one-third lighter than its closest rival. Put this extra lightness to work improving your products. Materials handling equipment, business machines, portable tools, truck bodies, and reciprocating machinery are but a few of the fields where magnesium lightness has been used to great advantage.

Maximum lightness isn't all magnesium has to offer. It's the easiest of all metals to machine and is readily adapted to all standard fabricating techniques. Available in all common forms, magnesium is surprisingly low in cost.

See how leading designers in many fields have used magnesium to improve their products. Send for your free copy of "How Magnesium Pays."

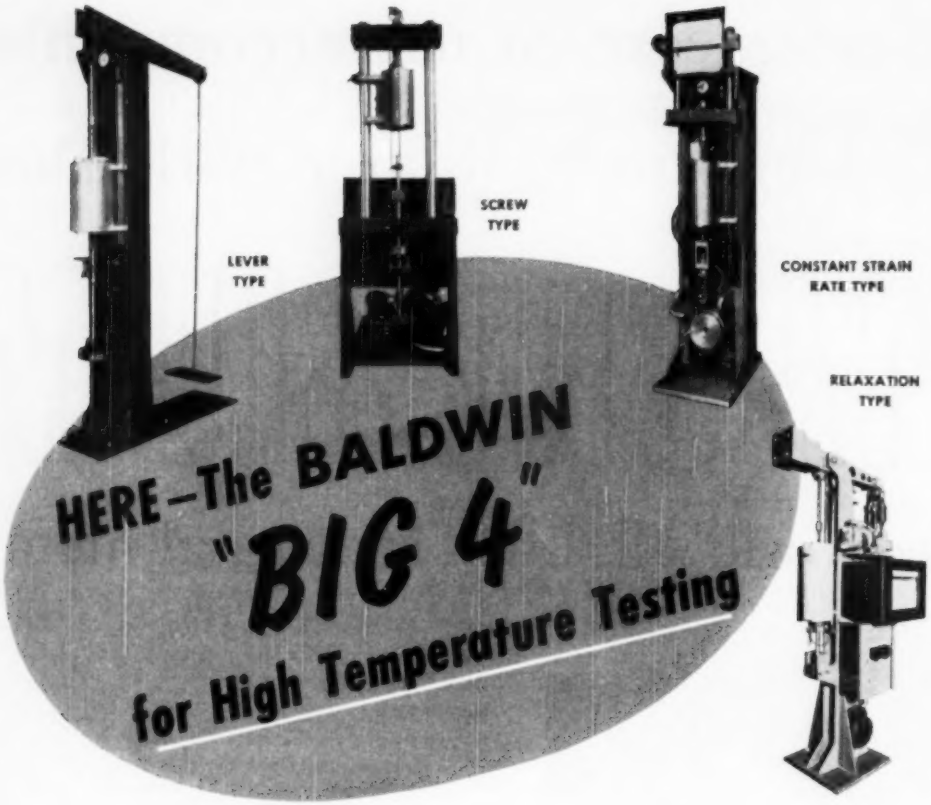
THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

Simplify Product Design— Speed Production and Assembly . . . with Magnesium

Leading manufacturers are using magnesium wherever they can. They've found that magnesium is as versatile and workable as it is light. Magnesium extrusions streamline design and production because they are available in an almost unlimited variety of shapes. Magnesium sand castings provide good strength, shock resistance and ease of machining. Magnesium sheet is strong without being heavy and is readily fabricated by well-known methods.

Lighter Products Sell—make your product Magnesium Light!



HERE—The BALDWIN "BIG 4" for High Temperature Testing

These Baldwin testing machines have opened the door to many important new developments, by providing the designer with accurate knowledge of the properties of stressed materials under elevated temperatures. You'll find them invaluable aids in your investigations in this exciting new field.

BALDWIN LEVER TYPE CREEP MACHINE. An extremely popular type; almost 200 are now serving in dozens of laboratories throughout the country. Maximum capacity 12,000 lb. Loading accuracy is within 1% of load, and accuracy of strain measurement is within 0.00005". Ask for Bulletin 272.

BALDWIN SCREW TYPE CREEP RUPTURE MACHINE. Automatically maintains loads while temperature is held constant. Motor driven, capacity 20,000 lb. Flat recorder chart plots elongation vs. time. Information will be furnished on request.

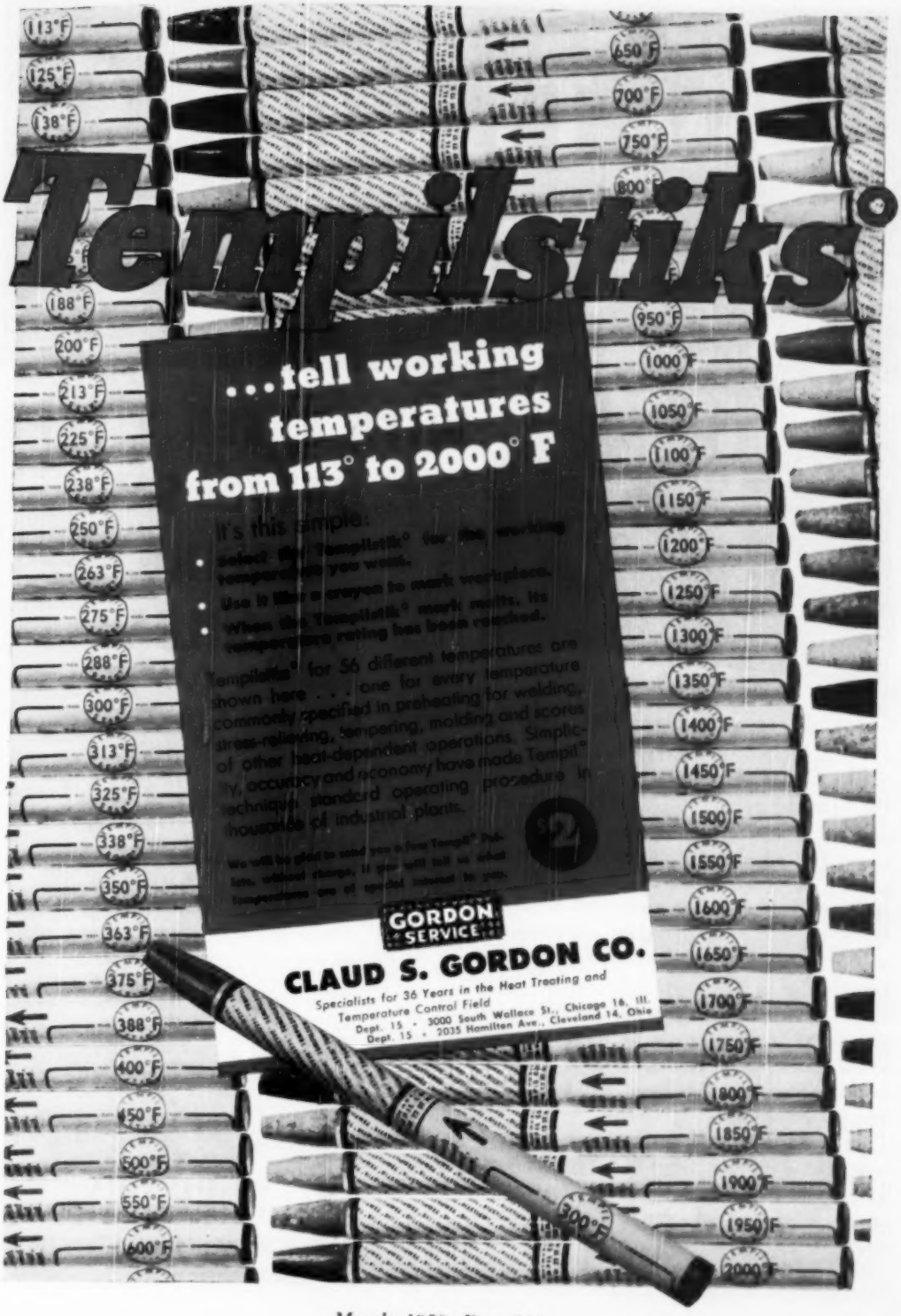
BALDWIN CONSTANT STRAIN RATE CREEP TESTING MACHINE. Determines the effect of various strain rates on the breaking points of metals, at controlled high temperatures. Head velocity can be varied from 0.5" to .000001" per second. Ask for detailed information.

BALDWIN RELAXATION TESTING MACHINE. Automatically carries out relaxation tests, providing a record of decline of load, in strain increments of only 0.000002" per in. Produces a curve of stress vs. time on a flat chart. Capacity, 4000 lb. Accuracy is approximately 1% of load or .25% of capacity. Details on request.

Standard furnaces furnished with above equipment give temperatures up to 1800°F. Special furnaces available to provide temperatures up to 2200°F. Control limits are ±5°, or ± 2°, depending on controller used.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U.S.A.
Offices: Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, Washington.
In Canada: Peacock Bros. Ltd., Montreal, Quebec.

BALDWIN TESTING HEADQUARTERS


Tempilstiks®
...tell working temperatures from 113° to 2000° F
It's this simple:
Tempilstiks® for 56 different temperatures are shown here . . . one for every temperature commonly specified in preheating for welding, stress-relieving, tempering, melding and scores of other heat-dependent operations. Simplicity, accuracy and economy have made Tempil® technique standard operating procedure in thousands of industrial plants.
$2
GORDON SERVICE
CLAUD S. GORDON CO.
Specialists for 36 Years in the Heat Treating and Temperature Control Field
Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

NEW LOW TESTING RANGES!

WITH OLSEN "L" TYPE UNIVERSAL TESTING MACHINE

"Atcotran" Electronic Null System now available on New Olsen "L" Machines — or can be added to present units.

The Olsen low cost "L" Universal Testing Machine now becomes more versatile than ever. Available in standard capacities of 60,000 lbs., 90,000 lbs., 120,000 lbs., 300,000 lbs., and 600,000 lbs. with usual selected secondary ranges of 10,000 lbs., 20,000 lbs., 30,000 lbs., 60,000 lbs. and 100,000 lbs. respectively—new "extra low" capacity ranges are now possible on these machines with the addition of the "Atcotran"* unit. For example, a 60,000 lb. and 10,000 lb. machine can be readily provided with an extra low range of 1,000 lbs., reading by 2 lb. dial marks. And in addition, load changes may be made without stopping the test.

For accurate tension, compression, and transverse testing the new Olsen "L" Type Universal is unsurpassed for versatility and low cost — whether used for production, and quality control testing or instruction.

Write today for complete information.

*The "Atcotran" was developed in conjunction with the Automatic Temperature Control Company, Philadelphia. An electronic null system consisting of only three moving parts, it receives signals from the developed hydraulic pressure in the precision cylinder of the "L" machine and electronically translates them into the rotary motion of the pointer. This system is extremely accurate and the low ranges which it makes possible are guaranteed accurate within ASTM requirements.

TINIUS Φ OLSEN

Testing & Balancing Machines

TINIUS OLSEN
TESTING MACHINE CO.
2030 Easton Rd., Willow Grove, Pa.

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Division, Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

High-Chromium, High-Carbon Iron

. . . the Iron That Hardens as it Wears

In many applications involving extreme abrasion, ordinary work-hardening alloys are not suitable. This is because most of these alloys require a definite pounding action for a martensite transformation, and the scouring action of an abrasive is not sufficient for development of high wear resistance. For this reason, high-chromium, high-carbon irons were developed -- irons that wear-harden.

Chromium Content of Irons Ranges from 24 to 30 Per Cent

These irons are made in the electric furnace and have the following composition range:

Chromium	24 to 30 per cent
Carbon	2.25 to 2.85 per cent
Manganese	0.50 to 1.25 per cent
Silicon	0.50 to 1.50 per cent
Nickel	minimum
Iron	balance

Irons of this composition are readily castable by steel casting techniques.

Development of Greater Wear Resistance by Heat Treatment

Structurally, these irons consist of primary iron-chromium carbides in a matrix of iron-chromium solid solution and secondary iron-chromium carbides. They are hard in the as-cast condition (500 to 550 Brinell), but when they are given an austenitization heat-treatment they develop much higher hardness (about 600 Brinell), and also have greatly improved wear resistance. Austenitization consists of heating these irons to a temperature of about 2012 deg. F. for an hour, then allowing them to cool in air. This heat-treatment promotes the formation of very unstable austenite--austenite that will transform to a harder martensitic end-product even under rubbing or mild impingement action. Austenitization has been found to be far more effective in increasing wear resistance than the promotion of unstable austenite by the addition of ferrite-forming alloying elements.

High-chromium, high-carbon irons can also be annealed to sufficiently low-hardness values for grinding or simple machining. Hardnesses as low as 350 to 450 Brinell can be obtained by heating the castings to temperatures of 1400 to 1450 deg. F. for 12 to 24 hours, then allowing them to cool in air.

Irons Have Wear Resistance Many Times That of Other Alloys

Austenitized high-chromium irons have been known to last as much as 21 times longer than other wear-resistant alloys in applications involving extreme frictional abrasion. These applications include sand-blast nozzles and liners, pantograph contact shoes, grinding disks, pulleys, chute-liner plates, dredge-pump liners, and rollers for crushing various hard materials.

In a recent test, high-chromium iron was compared to special wear-resistant steel castings as the material for hammers in a machine that was used to crush abrasive material. The chrome-iron hammers were found to have almost 7 times the wear resistance of the steel castings.

Fig. 1. After crushing the same amount of abrasive material in a hammer mill, the badly worn steel casting (left) had a weight loss of 37 per cent while the high-chromium iron casting (right) lost only 5.5 per cent.

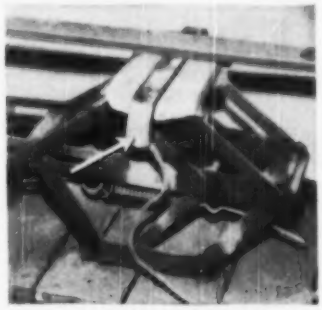


Fig. 2. This chrome-iron pantograph shoe had a service life of about 10 years. A tool steel that was used in similar service wore out in about 3 or 4 months; copper lasted about 24 hours.

When thoroughly backed up with zinc, the iron also has enough shock resistance to be used effectively as crushing hammers and jaw plates for many severe rock-handling jobs.

Metallurgical Service Available

For years, ELECTROMET high-carbon ferrochrome has been used to make chromium additions to abrasion-resistant high-chromium irons. If you should have any questions about either the production or use of these irons, write to the nearest ELECTROMET office. Our metallurgists will be glad to give many valuable suggestions and recommendations on how to make or use this iron most effectively.

Write for a free copy of the ELECTROMET publication, "Abrasion-Resistant High-Chromium Iron." This booklet is a collection of some of the best available information on how to make and to use abrasion-resistant iron castings most efficiently.

The term "Electromet" is a registered trademark of Union Carbide and Carbon Corporation.

POWDER METALLURGY
the modern method
of manufacturing

KUX PRESSES

THE MACHINES
UNIVERSALLY USED

POWDER METALLURGY is the process being chosen for the manufacture of many products because of the cost savings produced from this automatic, high speed production method. Parts such as porous, self-lubricating bearings, carbon brushes, and insulators, Alnico magnets, carbide tool bits, magnetic radio cores, contact buttons, gears, cams and literally thousands of other items are accurately and automatically made with unbelievable cost savings on Kux Presses.

BUILDERS of the most complete line of machines available for this industry, Kux Presses have been selected by all the leading manufacturers for the superiority in design and construction built into every model. A penny post card will bring you detailed information and an illustrated catalogue.

KUX

KUX MACHINE COMPANY
3940 W. HARRISON STREET • CHICAGO 24, ILLINOIS

(Partial view of the enormous new lubricating oil plant at Lake Charles, La., where this great new oil is processed.)

"ANTI-FOULING" OIL made by the Remarkable new "HEART-CUT" PROCESS

This new oil—the best known to science... gives you a cleaner engine...more economy ...minimum carbon residue.

It's here now! The remarkable motor oil from the giant new $42,000,000 lubricating oil plant at Lake Charles, La. The plant that's been the big talk of the oil industry for months.

New Premium Koolmotor is made by the unique "Heart-Cut" Process which retains only the choicest part of the finest crudes. *It's so superior that in recent engine tests it outscored nine other major premium motor oils.* No wonder Premium Koolmotor is better in every way! Cleans better, seals better, cools better and fights acid, sludge and corrosion far more effectively. Switch to this remarkable new oil today.

start saving Dollars today...stop at

CITIES SERVICE

MICROCASTING

Eliminates 15 machine Operations

AT 1/3 THE COST

Microcast Part: **Cutting Knife**
Utilization: **Knitting Machinery**
Alloy: **Stellite "J" Metal**
Weight: **7 Grams**

This part was previously made from a free-machining alloy and was shaped, drilled and ground. 15 machine operations were required. As the metal was relatively soft for the purpose of the part, replacements were heavy. The Microcast Process of precision casting produced this same part with only a grinding operation required. Because the Microcast Process eliminated virtually all machining operations it was practicable to utilize the extremely hard Stellite "J" Metal for a longer life. This Microcast part was produced for 1/3 of the cost of the previous method.

MICROCAST T. M. REG. U. S. PAT. OFF.

Microcast components of intricate shape may be produced of the extremely hard, high melting point alloys because as cast they are dimensionally uniform, of sound structure and to such close tolerances that little or no machining is required.

WRITE FOR FREE BOOKLET—More complete information on the Microcast Process is contained in a 16-page booklet which describes many applications for Microcast, specifications and a step-by-step explanation of the process itself. Write for this valuable booklet today!

MICROCAST

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

Editorial Summary of March Metal Progress

REVOLUTION IN BRASS MAKING • "It is true that the brass industry is now in the midst of a revolution so profound that we who are involved have difficulty in realizing its full scope. It is a revolution of equipment." So wrote a leading metallurgist in 1948. Furnace builders are proving his point. . . . . p. 327.

METAL FOR FIRE BOXES • Vital parts of a jet engine in surprising number are made of sheet metal, and some of these parts work at the highest temperature. Hence the development of a new alloy sheet that boosts the working temperature 300° is metallurgical news of first importance. . . . . p. 321.

TAMING THE INTERNAL STRESS • Internal stresses are known to be due to heat treatment, but their magnitude is only guessed at — until they cause spontaneous fracture! Even minor stresses, in the wrong direction, cause early breakdowns. For hints about how to make them work *for* you, read p. 349 and following.

SPEEDY PIPE FINISHING • "Deliberate" is the word to describe the pace at which seamless tube is drawn through finishing dies. But more speed is possible. Also three dies can be put in a single die block. Result: Ten times the production! . . . . . p. 335.

BETTER CARBIDE TOOLS • Size and shape of carbide grains and disposition of metallic binder is affected by the purity of the tungsten carbide, the presence of alloy, and various factors in processing. The electron microscope is now being used to correlate the above variables with performance of standard cutting tools. . . . . p. 341.

DESCALING HIGH ALLOY • From the superior corrosion resistance of high chromium-nickel alloys one naturally expects trouble in descaling operations. He is not disappointed! A great help is the use of a molten sodium hydride bath. It cleans well a wide variety of commercial alloys. . . . . p. 340.

CORRECT NITRIDING PRACTICE • Important machine parts are often nitrided to improve their endurance. Sometimes it doesn't work! ✪ Past-President Boegehold believes that such failures are due to cases of improper thickness in proportion to the core. . . . . p. 353.

WHAT'S IN A TEST? • Russian metallurgists are debating the real meaning and utility of the common mechanical tests, although the umpire says that it is impossible to agree with some of the debaters, and promises to adjust the conflicts. (Is this a prophecy or a threat?) . . . . . p. 358.

FORMABILITY OF SHEET • Since sheet metal was first hammered into a stew pan the characteristics that make for "formability" have been elusive. Enough is now known, however, so the metallurgist can separate the good from the not-so-good, and thus avoid expensive troubles in the press and stamping shops. . . . . p. 325.

MODERN HEAT TREATING EQUIPMENT • The field for economical heat treatment of metal in molten salt has been greatly extended in the last decade. Messrs. Adam and Rosseau state briefly the reasons for this prodigious growth. . . . . p. 332.

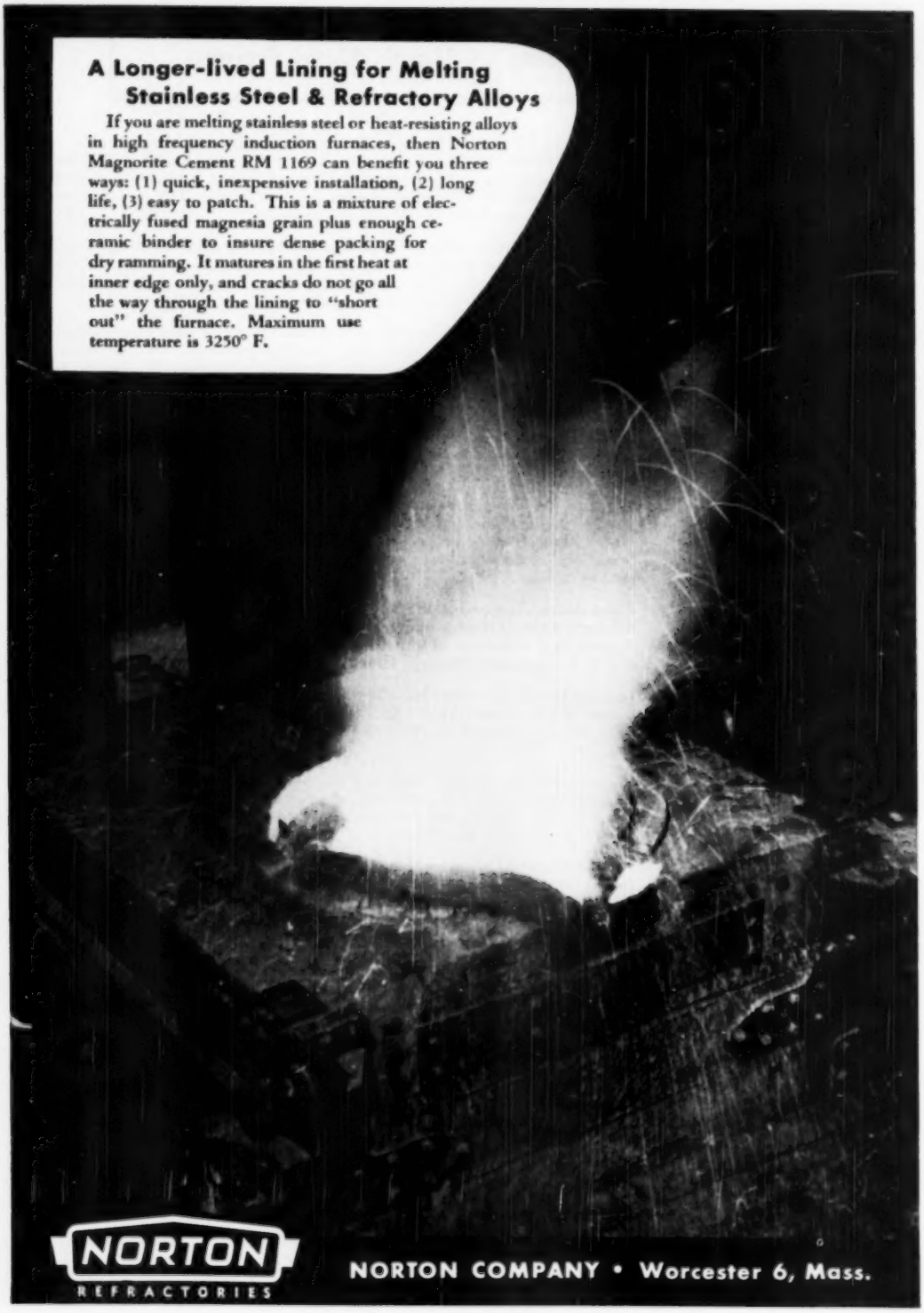
POISON METAL • General warnings that beryllium is poisonous — even that it is five to ten times as toxic as mercury — are less valuable than detailed information about proper ventilation, hoods, and safe methods of performing ordinary manipulations. . . . . p. 345.

ELECTROPLATE ON LEAD • Lead — a metal used since ancient times for its corrosion resistance — is nevertheless most difficult to clean, prior to plating. Consulting Editor Bregman notes a tried and effective method. . . . . p. 339.

NEXT MONTH : Sonic Inspection of Jet Engine Rotor . . . Improving Blast Furnace Practice . . . The Quenching of Gears . . . Liquid Cyaniding . . . Hardenability . . . Indexing of Metallurgical Information . . . Fatigue of Compressor Valves

A Longer-lived Lining for Melting Stainless Steel & Refractory Alloys

If you are melting stainless steel or heat-resisting alloys in high frequency induction furnaces, then Norton Magnorite Cement RM 1169 can benefit you three ways: (1) quick, inexpensive installation, (2) long life, (3) easy to patch. This is a mixture of electrically fused magnesia grain plus enough ceramic binder to insure dense packing for dry ramming. It matures in the first heat at inner edge only, and cracks do not go all the way through the lining to "short out" the furnace. Maximum use temperature is 3250° F.



NORTON
REFRACTORIES

NORTON COMPANY • Worcester 6, Mass.

Metal Progress

The Magazine for Metallurgical Engineers

March 1950
Vol. 57, No. 3

Editor

Ernest E. Thum

Associate Editor

Taylor Lyman

Consulting Editors

Adolph Bregman
Harold J. Roast

Advisory Board

Albert W. Demmler
O. W. Ellis
A. E. Focke
Muir L. Frey
J. D. Hanawalt
Walter Jominy
L. A. Lindberg
Howard Scott

Cover Artist is Carl Sorensen

Copyright, 1950, by AMERICAN SOCIETY FOR METALS, 7301 Euclid Ave., Cleveland 3, Ohio. Published monthly; subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879 . . . The AMERICAN SOCIETY FOR METALS is not responsible for statements or opinions printed in this publication . . . Requests for change in address should include *old* address of the subscriber; numbers missing due to "change in address" cannot be replaced . . . claims for undelivered copies must be made within 60 days.

Table of Contents

Technical Articles

New Cobalt-Base Alloy for High-Temperature Sheet . . . 321
by W. O. Binder and H. R. Spendelow, Jr.

Large Continuous Furnaces for Annealing Brass . . . 327
Staff Report

Modern Heat Treating: I — The Salt Bath . . . 332
by William Adam, Jr. and Leon B. Rosseau

Metal Cleaning Problems and Tests for Cleaners . . . 339
by Adolph Bregman

Electron Metallography of Cemented Carbides . . . 341
by William L. Grube

Control of Atmospheric Beryllium . . . 345
by Norman P. Pinto

Atomic Diameters of Metallic Elements . . . 348
by Pol Duwez

Test Bar Results Compared With Tests on Components . . . 349
by A. L. Boegehold

Russian Opinions on Evaluation of Metals by Mechanical Tests . . . 358
Reviewed by E. P. Klier

Critical Points by the Editors

Evaluating Mechanical Tests; Residual Stresses; Fast Work at the Draw Bench; We May Start Again From Protozoa 335

Correspondence

Uranium as a Metallographic Aid . . . 336
by E. H. Rowe

Pretreatment of Aluminum Sheet (a Correction) . . . 336

Radial Structure of Graphite Nodules . . . 337
by M. Hatherly and L. E. Samuels

Identifying Ball Anodes . . . 337
by C. Goldberg

Testing Adhesion in Glass-Metal Seals . . . 337
by Norman Allen

Prefabricated Aluminum Houses . . . 338
by Tom Bishop

Abstracts

Correlation of Tests . . . 368
Abstracted from *Welding Journal.*

Fundamental Properties . . . 407
Abstracted from *Revue de Metallurgie.*

Chromium Plating . . . 410
Abstracted from *Journal of the Electrochemical Society.*

Departments

Data Sheet: Atomic Diameters of Metallic Elements 348-B
by Pol Duwez

Personals . . . 360, 362, 364, 366

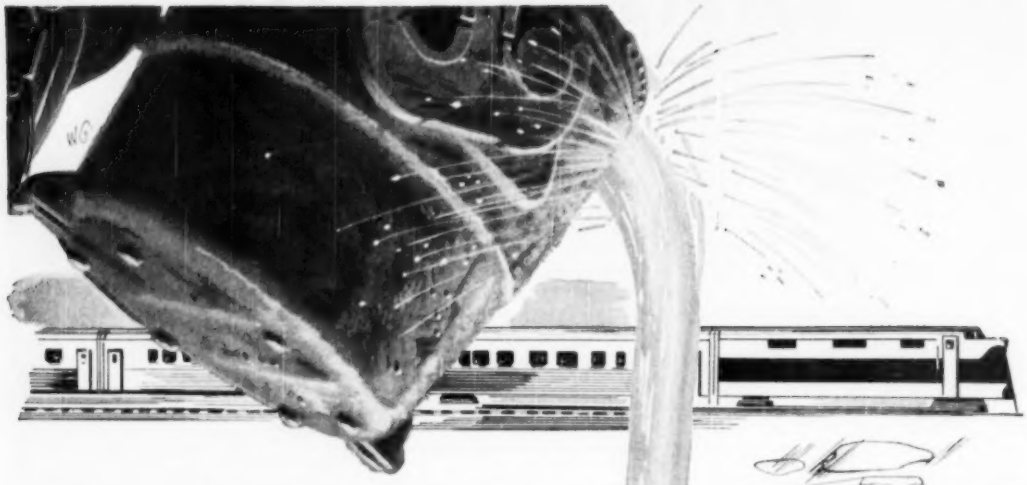
Engineering Digest of New Products . . . 376, 378, 380

Manufacturers' Literature . . . 380-A, 380-B

Advertisers' Index . . . 412

Published by

THE AMERICAN SOCIETY FOR METALS



cut operating costs, increase payloads —reduce weight or increase strength

with Inland HI-STEEL

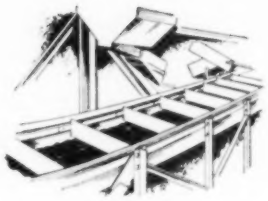
Inland HI-STEEL's high strength-to-weight ratio and its abrasion and corrosion resistance permit longer life, weight reductions up to 25%, and greater strength than ordinary structural-grade carbon steel.

These properties permit three different approaches to the problems of design and construction:

1. To design for same strength with reduced weight and greater payloads;
2. To design for greater strength with same weight and payload; and
3. To design for compromises that will allow variations of these qualities.

In each case operating costs of mobile equipment are greatly reduced.

And Inland HI-STEEL can be worked either hot or cold—punched, drawn or otherwise fabricated—welded or riveted—with little or no change in shop practice.



COMPARISON OF *AVERAGE* PROPERTIES OF HI-STEEL WITH ORDINARY STRUCTURAL GRADE CARBON STEEL

Tensile Properties (¼" Plate)	Inland HI-STEEL	Ordinary Structural Grade Carbon Steel
Yield Point (psi)	56,000	35,000
Ultimate Strength (psi)	73,000	66,000
Elong. in 8" (%)	25	25
Endurance Limit		
Fatigue Strength (psi)	49,000	33,000
Impact Resistance (Charpy Impact—ft. lbs.) Temperature		
80° F	55	36
32° F	43	33
0° F	36	26
—25° F	34	6
—50° F	30	2

INLAND STEEL COMPANY
Dept. MP30, 38 S. DEARBORN ST.
CHICAGO, ILLINOIS

Write for Booklet

Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

INLAND

OTHER PRODUCTS: BARS • PLATES STRUCTURALS • SHEETS • STRIP • TIN PLATE • SAFETY PLATE • PILING • RAILS • TRACK ACCESSORIES.

New Cobalt-Base Alloy for High-Temperature Sheet

By W. O. Binder
and H. R. Spendelow, Jr.
Research Metallurgists
Union Carbide & Carbon Research Laboratories
Niagara Falls, N. Y.

A superior high-alloy sheet, for use at temperatures up to 1800° F., has been based on cobalt (50%), chromium, nickel and tungsten. While strong and stiff, it can be readily formed in bending, stamping and drawing, has good weldability, and high resistance to oxidation. To develop optimum properties a short heating at 2200° F., followed by air cooling, is all that is necessary.

DURING WORLD WAR II the austenitic 18-8's and the Ni-Cr alloys were the principal sheet metals for high temperature service. They possess exceptional ductility and formability; also good strength and oxidation resistance at elevated temperatures.

To meet the more stringent requirements of gas turbine rotors and buckets, extensive wartime investigations in many laboratories resulted in several improved alloys. Some of them are now available in the form of sheet. However, there was a need for a sheet material combining good formability with high strength at 1700 to 1800° F. for sheet metal components of gas turbines. In order to fill this need, Union Carbide and Carbon Research Laboratories, Inc., undertook, at the request of the Haynes Stellite Division of Union Carbide and Carbon Corp., a broad program of research which has been in progress for the past several years.

While the requirements for such an alloy have not yet been defined exactly, they include the following items:

High strength up to 1800° F.
Resistance to oxidation and carburization up to 1900° F.
High fatigue strength against mechanical and thermal stresses.
Satisfactory weldability. (This usually means a low carbon content.)
Good workability in fabrication. (Hot workability usually requires low carbon.)

Information from fabricators (for example, Solar Aircraft Co.) indicates that alloys with less than 35% elongation in 2 in. or 50% in 0.2 in. are generally unsatisfactory for forming operations.

Further desirable requirements (although not limiting for critical service) are as follows:

A solution heat treatment that is below the temperature for rapid scaling.
No necessity for a rapid quench.
No required aging heat treatment.

The history of developments in this field of metallurgy indicates that the above formidable list of requirements can best be filled by an alloy of cobalt, chromium, iron and nickel that derives its hot strength from alloying metals (such as molybdenum, tungsten, vanadium, columbium, titanium and tantalum). These elements have a limited solubility in the austenitic (face-centered cubic) matrix and precipitate in the service-temperature range as complex intermetallic compounds or carbides. During solution treatment at relatively high temperatures, most of the compounds dissolve in the austenitic matrix and they are kept in solid solution by rapid cooling. As is well known, subsequent reheating — considerably lower than the solution heat treating temperature — causes precipitation hardening. Since some degree

of aging occurs during service at high temperature, a pre-aging treatment is often omitted. In any event, the precipitation hardening range should be within or above the normal service temperature range if maximum hot strength is required.

The alloy resulting from this investigation, designated during its development as L-605 and more recently marketed as "Haynes 25" alloy, has excellent hot ductility; consequently it can be forged or rolled into bars or rolled into sheet. Solution heat treatment is at 2200° F. — not too high for thin sheet. Aging occurs at the operating temperatures; no significant improvement in rupture life results from aging at lower temperatures. Its nominal composition is 20% Cr, 15% W, 10% Ni, 1.5% Mn, 0.5% Si, <2.0% Fe, 0.10% C and the balance (50% ±) Co.

In the solution heat treated condition, its yield strength is about 70,000 psi., ultimate tensile strength 155,000 psi., elongation in a 2-in. gage length upward of 50%. Cold formability indicated by tensile tests has been amply confirmed in actual fabrication. The stress-rupture properties (stresses for the same rupture times) are about 25% higher than for the excellent N-155 alloy.

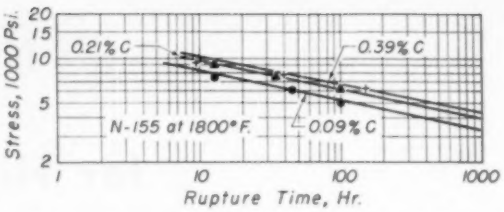


Fig. 1 — Increased Carbon Raises Somewhat the Rupture Stress of Low-Carbon N-155 Alloy at 1800° F.

Experimental Conditions

All the alloys in the broad experimental program on alloy sheet metal were melted from virgin raw materials of high commercial quality in a small high-frequency furnace. The lower half of a 2-in. square ingot was scalped, reduced to ¼ in. thickness, pickled, surface defects ground out, and then rolled to 16 gage. After annealing, mill scale was pickled off in hot (160° F.) 20% HNO_3 solution containing 2% HF.

Test specimens were sheared from the 16-gage strip with length parallel to the rolling direction; A.S.T.M. reduced sections of ½ in. over a 2-in. gage length were formed by milling with a carbide tool, with a light grinding to finished size. Specimens were heat treated after machining to eliminate any work hardening of the edges.

Since conditions during deep drawing are different from those in ordinary tension tests, drawing qualities were experimentally evaluated by a wedge-draw test similar to that described by Brewer and Rockwell in *Metal Progress* for May 1942.

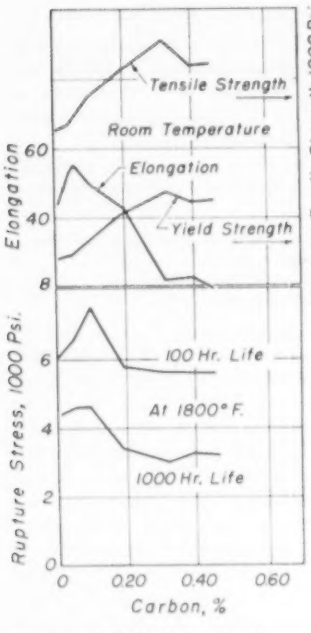


Fig. 2 — 0.10% Carbon in Haynes 25 Is About Optimum for Ductility (Cold) and Strength at 1800° F.

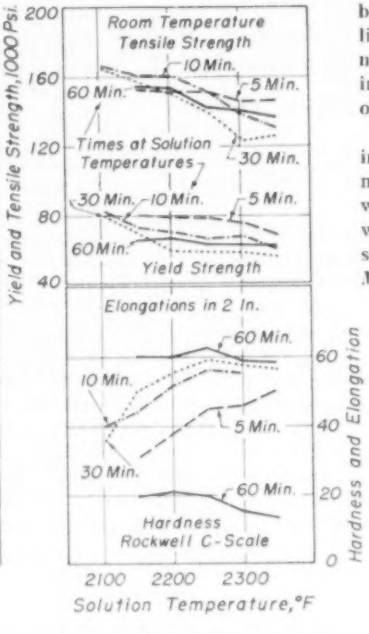


Fig. 3 — High Elongations in 16-Gage Sheet From Production Heat of Haynes 25 Alloy Are Produced by Heating 10 Min. at 2200° F.

Effect of Carbon on Strength at 1800° F.

The low-carbon N-155 alloy (nominally 20% Cr, 20% Ni, 20% Co, 3% Mo, 2% W, 1% Cb, 0.12% C, 0.12% N, balance Fe) was designed primarily for service at about 1500° F. max. However, the alloy has already been used for the manufacture of engine components and aircraft cabin heaters where the operating temperatures are considerably higher. In view of this, it appeared desirable to investigate the possibilities of improving the

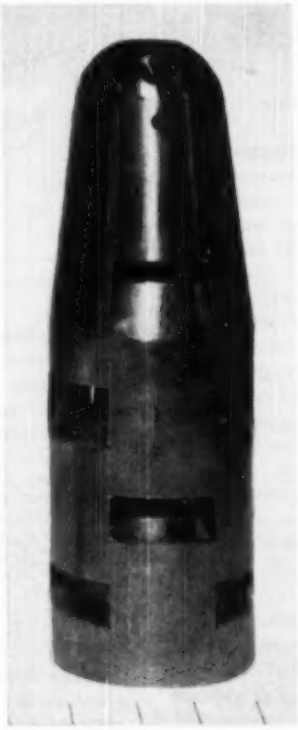
high-temperature strength of the N-155 alloy before attempting the development of a new alloy.

From the point of view of desirable austenite stability it was decided to limit the modifications of the N-155 alloy to a study of the influence of higher carbon contents on the strength of the alloy. Rupture tests were made at 1800° F. on 16-gage sheet from three heats of N-155 alloy with carbon contents of 0.09, 0.21, and 0.39%. All specimens were solution heat treated for 1 hr. at 2200° F., and then aged for 16 hr. at 1400° F. The data, summarized in Fig. 1, indicate that higher carbon contents increase the rupture strength of the alloy at 1800° F. However, the increase was not considered sufficient, when weighed against the disadvantages of higher carbon contents, to encourage further development work with this class of alloys (20% chromium, 20% nickel, 20% cobalt) for service at 1800° F.

Work was, therefore, initiated on cobalt-base alloys higher in total hardening alloy content, and led to the selection of the L-605 composition, now known as Haynes 25, of the general type 20% Cr, 15% W, 10% Ni, and 50% Co. Since higher carbon content improved the hot strength of N-155, it was decided to investigate its influence in this new combination over a wide range, although from the standpoint of hot workability, weldability, and less critical heat treatment, it would be desirable to keep the carbon low.

Stresses to produce rupture in 100 and 1000 hr. at 1800° F. and room temperature tensile data on this high cobalt alloy containing 0.006 to 0.48% carbon are given in Fig. 2. All samples were solution heat treated for 5 min. at 2200° F. and air cooled. Maximum cold ductility and hot strength occur at about 0.10% carbon. Apparently, carbon in solid solution imparts some high-temperature strength, but an excess depletes the matrix of alloy hardening elements, causing a loss in hot strength.

Strength at 1500° F.—While maximum strength at 1700 to 1800° F. occurred at a carbon content of about 0.10%, past experience with other alloys has led to the belief that increased strength at lower temperatures can be developed only at the higher carbon levels. However, stress-rupture tests conducted at 1500° F. on alloys containing up to 0.30% carbon showed no significant influence of carbon on rupture strength. All the test points fell within a narrow band in the range of 20,000 to 30,000 psi. stress, showing no significant influence of carbon in the range investigated. Consequently, no compromise in the composition of the alloy, with respect to carbon, appears necessary to obtain a material whose rupture characteristics are generally satisfactory over the entire temperature range of 1500 to 1800° F.



Jet Engine Combustion Chamber Heliarc Welded by Alloy Products, Inc.

Tests on a Heat Made in Production

It remained to determine if the properties developed in small laboratory heats could be duplicated in large-scale operation, so a production size heat of this alloy, designated CG-2, was made and fabricated into bar stock, plate, and 16-gage sheet. Its mechanical properties at room temperature are summarized in Fig. 3, which shows the influence of solution heat treating times up to 1 hr. at temperatures from 2100 to 2350° F.

While the data indicate a trend toward higher elongations with increasing solution temperatures and times, elongations of more than 50% (which are adequate for most forming operations) result from about 10 min. at 2200° F., followed by air cooling.

Some additional tensile tests were made to determine the effect of sheet thickness on the tensile strength and elongation in 2 in., and whether the sheet exhibited directional properties. These tests were made on a second heat, commercially melted and fabricated. Specimens were cut longitudinally and transversely with respect to the rolling direction of the sheet, and solution heated 10 min. at 2200° F. and then air cooled. The results are given at the top of p. 324, from which it may be concluded that the rolled sheet possesses no marked directional properties. Furthermore, thickness of the sheet does not appear to have any effect.

Directional Uniformity

Sheet	Transverse Tensile	Transverse Elongation	Longitudinal Tensile	Longitudinal Elongation
0.025 in.*	144,500	52.7	143,200	52.8
0.040 in.*	146,300	58.7	145,300	58.9
0.065 in.	145,500	65.0	149,500	62.0
0.138 in.	150,000	59.5	150,000	62.0

*Averages for three specimens

Erichsen tests were made on 0.038-in. sheet specimens (rolled from Heat CG-2) that were solution heat treated for 1 hr. at temperatures ranging from 2150 to 2350° F. by 50° increments. Depths to fracture were 10.3, 11.2, 11.2, 10.9, and 10.5 mm. respectively, thus supporting the conclusion from the tension tests that adequate formability may be developed by a solution treatment at 2200° F.

Hot Strength of 16-Gage Sheet

Stress-rupture tests were made on 16-gage sheet, rolled from Heat CG-2, in several different conditions of heat treatment noted in the caption of Fig. 4. An attempt was also made to determine if the material had directional stress-rupture properties.

The heat treatment of 10 min. at 2200° F. (the one favored on the basis of tests described earlier in this article) produced high strength. As forecast by the previous experiments relating heat treatment and cold ductility, service life at elevated temperatures was slightly longer after increased time or temperature of solution heat treatment. It is also evident that there is no improvement by an aging treatment. Extrapolation and interpolation of the rupture curves predict stress-rupture values for Haynes 25 as follows:

Temperature	100 Hr.	1000 Hr.
1700° F.	11,000 psi.	7,700 psi.
1800° F.	7,000	4,500

Figure 4 also shows that the material appears to be isotropic with respect to elevated temperature rupture strength.

Figure 5 compares the high-temperature rupture characteristics at 1800° F. of this alloy in 16-gage sheet form with the familiar materials, low-carbon N-153 and low-carbon N-155. N-153 and N-155 alloys were solution heat treated for 1 hr. at 2200° F., air cooled; then aged 16 hr. at 1400° F., and air cooled. The line for Haynes 25 (L-605) alloy is an average of all the test data reported for Heat CG-2 in Fig. 4.

Distribution of elongation near the point of fracture in a tension test piece is a matter of interest in appraising the formability or workability of sheet metal. A study of localized conditions ("incremental elongations") was made by photoprinting a fine grid of 0.05-in. spacing on the tensile specimen. The spacing was carefully measured after failure, and the percentage elongation for each original 0.05-in. element was then plotted as a function of its average distance from the fracture.

Such data for 16-gage sheet from commercial heats of four high-temperature alloys are plotted in Fig. 6. Room temperature mechanical properties are given in Table I.

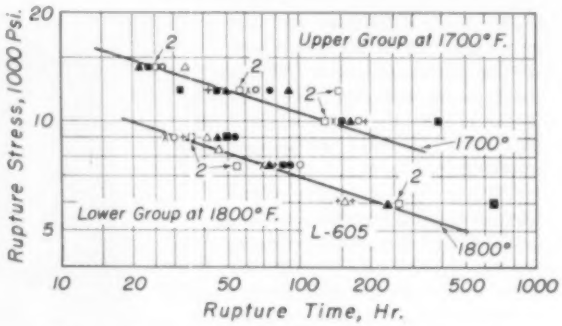


Fig. 4 — Summary of Stress-Rupture Data for 16-Gage Sheet of Haynes 25 (L-605), Commercial Heat CG-2. Heat treatment No. 2 is the preferred. Samples air cooled after all heatings. Samples cut parallel to rolling direction except as noted below:

1 + 5 min. 2200° F., air cooled
2 □ 10 min. 2200° F., air cooled
3 ▲ 30 min. 2200° F., air cooled
4 △ 5 min. 2300° F., air cooled
5 ■ 10 min. 2300° F., air cooled
6 X 20 min. 2300° F., air cooled +16 hr. 1400° F., air cooled
7 ○ 20 min. 2300° F., air cooled +16 hr. 1400° F., air cooled (normal to rolling direction)
8 ● 20 min. 2300° F., air cooled +16 hr. 1400° F., air cooled (45° to rolling direction)

Formability and Workability

The foregoing discussion shows that the new alloy meets the principal objectives of this investigation — namely, improved strength at 1700 and 1800° F., plus satisfactory cold ductility. However, the utility of a sheet material, all other factors being similar, depends upon its ability to undergo forming operations. While there is no single characteristic of a metal that may be used to evaluate this matter, F. R. Shanley states (in *Journal* of the Aeronautical Sciences for July 1942) that certain criteria for each general class of forming permit a comparison of different sheet materials.

A. Per cent elongation in ¼ in. evaluates capacity for short radius bends.

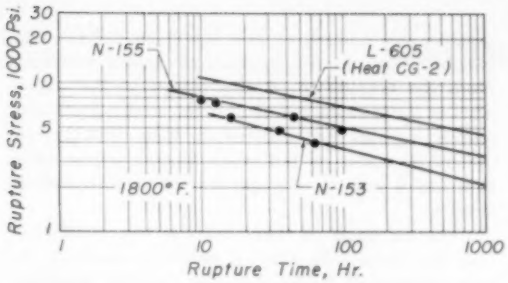


Fig. 5 — Rupture Strength at 1800° F. of N-153, N-155 and Haynes 25 (L-605), Tested as 16-Gage Sheet

B. Per cent elongation in 40 to 50 in. evaluates stretch forming capabilities.

C. Ratio of the tangent modulus at 4% elongation to the compressive yield strength is an index of shrink forming ability.

D. Ratio of the radius of the original blank to the radius of the cup after drawing is an index of deep drawability.

A comparison of the new alloy with low-carbon N-153 alloy, low-carbon N-155 alloy and Type 347 stainless steel, based on the above criteria, is given in Table II.

Criterion A (capacity for local bending and stretching) is given in the second column of Table II as percentage elongation in 0.05 in. nearest the line of fracture. On this basis, local bending properties of the new alloy are adequate for the forming of short-radius flanges, dimples, and so on. As indicated in Fig. 6, the new alloy work hardens to a much greater extent than the lower alloyed materials and exhibits about two thirds of the local deformation in the vicinity of the failure that the other materials undergo. However, the measured amount (71% in 0.05 in.) still exceeds the minimum necessary. It is also of interest to note the remarkable similarity in local bending characteristics of N-153, N-155, and Type 347 stainless steel, in view of their widely different total alloy content.

Table I — Comparison of Mechanical Properties at Room Temperature, 16-Gage Sheet

Property and Analysis	N-153★	N-155★	Type 347†	Haynes 25 (L-605)★
Yield strength (0.2% offset), psi.	53,000	53,000	33,000	70,000
Ultimate strength, psi.	114,000	115,000	86,300	155,000
Elongation in 2 in., %	40	45	50	60
Rockwell hardness	B-88	B-90	B-82	B-100
Type analysis: C	0.12	0.12	0.08	0.10
Mn	1.5	1.5	1.25	1.5
Si	0.5	0.5	0.5	0.5
Cr	16	20	18.5	20
Ni	15	20	11.5	10
Co	13	20	—	Balance
W	2	2	—	15
Mo	3	3	—	—
Cb	1.0	1.0	0.85	—
N	0.12	0.12	—	—
Fe	Balance	Balance	Balance	<2.0

★Heat treated 1 hr. at 2200° F., air cooled.
†Heat treated 10 min. at 1965° F., air cooled.

Stretch Forming

Criterion B (stretching of longer lengths) is given in the third column of Table II as the percentage elongation in 2 in. The new alloy appears superior in this respect to the others under comparison (which do not differ significantly among themselves). Comparisons based on a 2-in. gage length are not adequately informative, since stretch forming is affected by other factors such as gage length, width of sheet, yield strength, and notch sensitivity. Therefore, these data should be considered qualitative rather than quantitative.

Table II — Comparison of Formability Characteristics

Alloy	Shanley's Criteria				Erichsen Cup
	A	B	C	D	
N-153	112%	40%	7.4	1.65	10.8 mm.
N-155	103	45	7.9	1.65	11.2
Type 347	108	46	8.6	1.73	12.0
Haynes 25	71	60	7.1	1.40	11.2

Criterion C (compression without wrinkling) is given in the fourth column of Table II as the ratio between tangent modulus at 4% strain and the tensile yield strength. It is a measure of the

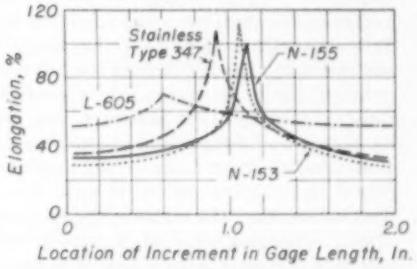
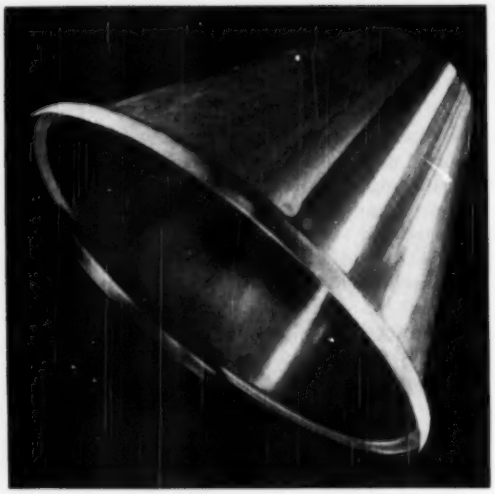


Fig. 6 — Incremental Elongations for High Temperature Alloys, Tested at Room Temperature (16-Gage Sheet)



Spun Cone, 11.25 In. High of 0.080-In. Sheet, Made by Spincraft, Inc.

ability to undergo compression in unsupported flanges without wrinkling. *Tensile* test data are applicable where the stress-strain relationships in compression are similar to those in tension, which is roughly true for these materials. The calculations were also made on the assumption that, for any given value of strain, the corresponding stress bears the same ratio to the yield strength. With these qualifications in mind, it appears that the new cobalt-base alloy is only slightly more susceptible to wrinkling than the older alloys, N-153, N-155 and Type 347 stainless.

Table III — Physical Properties

DENSITY: 9.15 g. per cu.cm.

COEFFICIENT OF EXPANSION (in./in./° F.) $\times 10^6$

Range, ° F.	N-155	L-605
70 to 600	8.70	7.61
70 to 1000	9.10	8.30
70 to 1400	9.77	8.92
70 to 1600	9.90	9.30
70 to 1800	—	9.70

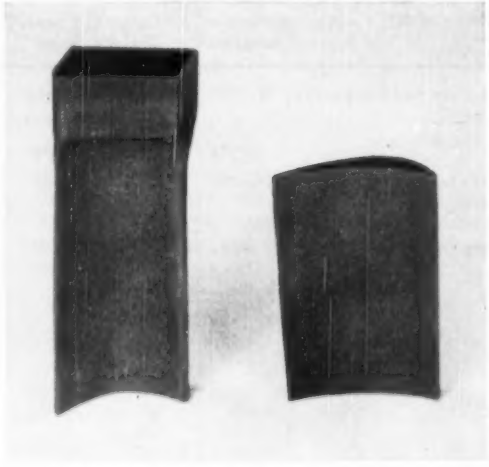
SPECIFIC RESISTANCE

N-153	33.7 microhms per cu.in.
N-155	36.6
Type 347	28 to 30
Haynes 25	34.9

The index of deep drawing (Criterion D) is given in the fifth column of Table II, which evaluates the "limit of drawing" as the quotient of R, radius of original round flat blank, and r, the radius of the smallest cylindrical cup that can be drawn therefrom. The figure for the new alloy is somewhat less favorable than for the older alloys, partially due to its tendency to work harden more rapidly. The test was similar to the one devised by Brewer and Rockwell, above mentioned, wherein a wedge-shaped specimen of sheet or thin plate is placed in a closely fitting tapered die, and then drawn through. The distance the specimen can be drawn (emerging as a strip with parallel edges before fracture) is simply related to the R/r ratio. Specimens of the new alloy broke with diagonal shear failures — another manifestation of work hardening. Edges of the drawn specimens were significantly ironed, so that the shear failure was probably due to propagation of cracks resulting from the exhaustion of slip planes at the edges. This is a condition created by the wedge-draw test and is not one encountered in deep drawing; in materials which do not work harden appreciably this factor can be disregarded when interpreting results.

On the basis of these tests, it was concluded that the Haynes 25 alloy is nearly comparable in formability with N-155 alloy and Type 347 stainless steel, although power requirements will be greater, as the new material is much stronger than the older alloys. These predictions have been substantiated by shop experience.

Numerous aircraft sheet metal parts ranging from small fabricated blades to larger afterburner assemblies have been fabricated from Haynes 25 (L-605) alloy. Deep drawing, spinning, stamping, drop hammer forging and similar operations have all been successfully carried out with this material. While complete technical data on welding are limited, welding has been successfully performed with roller seam, spot, "heliarc" and electric arc methods with comparative ease.



Hollow Turbine Blades Made by Deep Drawing and Press Forming (Turbo Products Co.)

Large Continuous Furnaces for Annealing Brass

Staff Report

Three articles on various features of Scovill Mfg. Co.'s new brass mill, of which this is the last, are warranted because the installations epitomize a fundamental change now going on in the nonferrous industry — namely, from hand operation of small units to mechanical handling of large units. Essential to this change toward true mass production are furnaces for fast annealing of stock, ranging from thick slabs to bulky coils. Two of America's outstanding furnace builders solved the many problems connected with this revolution in brass annealing.

SCOVILL'S new rolling mill at Waterbury, whose continuous casting department and general layout have been described in our last two issues, was under active development in 1945, when the war's end permitted some consideration of a long-range peacetime program. Certain units of the new mill, including the "short bar" annealing furnace now to be described, were so badly needed in current production that they were installed in the old hand mill, already crowded with equipment. Floor space was therefore a prime consideration. Safety and minimum of downtime is also essential in the new, continuous mill to avoid complete shutdowns. For example, the roller hearth of the annealing furnace, chain driven from an electric motor, has a stand-by gas engine and gearing for hand operation as well; if any single roller becomes stationary, an alarm bell rings.

Another unusual requirement was that the furnace be able to handle bars of varying size and length, weighing anywhere between the 350 lb. max. of the old hand mill and 2000 lb. max. for the continuous cast slabs. As the trend is toward large bars, the furnace was designed to take two bars 29 in. wide, side by side; bars up to 16 in. could be handled three at a time, side by side. Lengths might be between 10 and 42 ft.; thicknesses could vary from 0.40 to 1.75 in.

Various alloys were to be handled. While the principal output is to be 70-30 and 65-35 brass (plain or leaded), the other metals to be rolled include nickel-silver, red brass (85-15), commercial bronze (90-10) and gilding metal (95-5). Maximum temperature was to be 1650° F. (900° C.); range of grain size after annealing of 70-30 brass was to be 0.080 to 0.160 mm., which required the bars to be 0.5 to 1 min. at heat. Specified capacity of the furnace was 36,700 lb. per hr. based on 100% use factor and bars of 48-in. width; this was thought to be ample for the desired mill output of 33,000 lb. per hr. Such high capacity (77 lb. per sq.ft. of hearth area per hr.) is possible because of the excellent insulation built into the furnace structure, the conveying system that requires no carriers, the relatively low amount of heat carried out by cooling the roller hearth, and direct contact between metal to be heated and the heating medium.

In order to fit this furnace into the old mill, temporarily, a special preheat section was incorporated into the design by the Electric Furnace Co., the builders. As shown at the left end of Fig. 1, this consists of a rather new idea of flame impingement. Eight burners (alternately from right and left) direct flame down upon the top of the bars; an equal number fire into the space

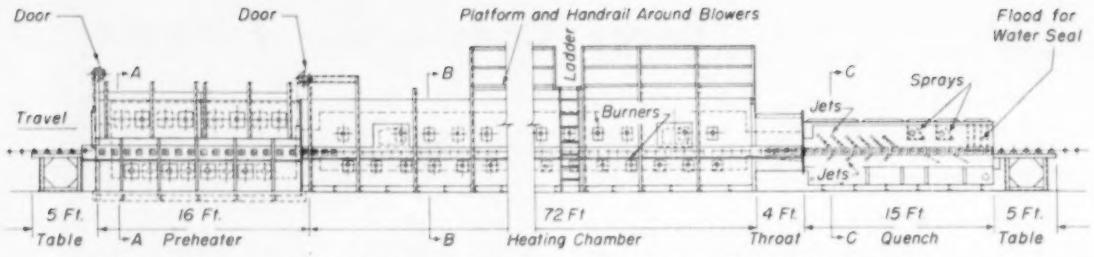
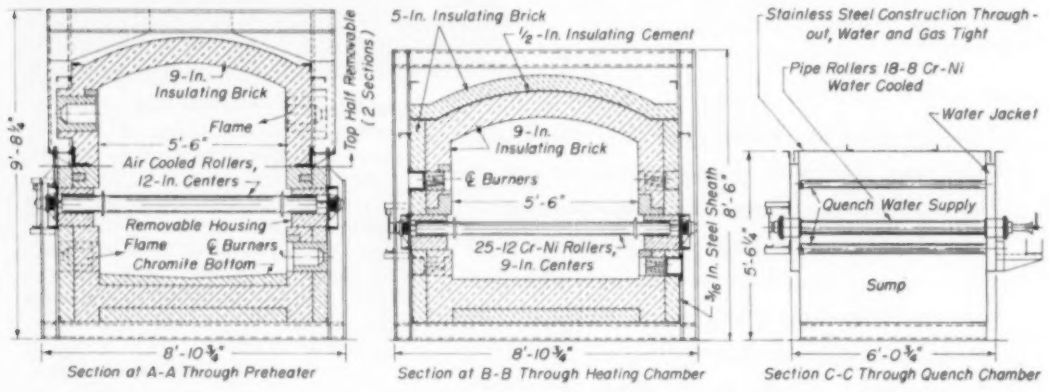


Fig. 1 — Elevation and Cross Sections of Short Bar Annealing Furnace Built by the Electric Furnace Co.



below the conveyer. This saves at least 50 ft. of the length otherwise required for conventional firing arrangements (the central portion of Fig. 1). The major portion of the heat is absorbed by the metal in this preheating chamber; the 72 ft. of heating chamber equalizes the metal and brings it up finally to the desired temperature for recrystallization and softening. In actual operation, this arrangement has worked very well indeed.

The furnace can be operated without the preheater, whereupon the central heating chamber can anneal about 16,500 lb. of brass per hr. (90% use factor).

As noted on the drawings, the preheater section has a removable roof in two sections, to be handled by an existing three-ton overhead crane. There are three peepholes for observation and a man-size door in the bottom for periodic clean-out. Sixteen low-pressure gas burners, each with pilot flames, utilize propane gas fuel; compressed air for combustion comes from one of the blowers shown in the photograph, Fig. 2. Automatic burner control in this section is from a single pyrometer working through a Wheelco "Throttltrol", which cuts off gas when the set temperature is exceeded, but the combustion air continues to flow and rapidly checks further temperature rise in the muffle. At full throttle, these 16 burners liberate 13 million B.t.u. per hr.

The entrance door is set to clear the incoming bars by a minimum safe clearance; some flame is forced out this slot and effectually seals out the air. A completely enclosed door (a brick-lined high-alloy frame) also separates the preheater from the heating chamber except for a slot to pass the work load. It is manually operated; an outside indicator shows its position. Between heating chamber and quenching chamber the metal passes under a swinging baffle whose lower edge just clears the bars passing through. This prevents intermixture of combustion gases in the heating chamber and steam in the quench.

Low-pressure, premix burners in the 72-ft. heating chamber are controlled in three zones, 30, 25 and 17 ft. long, respectively liberating 3.6, 3.0 and 1.8 million B.t.u. per hr. Automatic control from pyrometer in each zone is by a combination of volume and pressure regulators driven by mechanisms of the duration adjusting type. All burners are closed automatically if either gas or electric service fails. Propane gas is the fuel. Usual peepholes and access doors are provided.

Since the major portion of the production is

copper-base alloys containing zinc, full atmosphere control would be difficult. Furthermore, this is unnecessary since the bars are to be overhauled (surface milled) when they have been reduced to about 0.40 in. thick. Extreme care was taken in selecting the proper size and type of burners so that the turndown condition during normal operation would give the closest control on the ratio of gas and air. By means of auxiliary burners in the last two zones, all zones of the furnace equipment can be heated to operating temperature at approximately the same rate after a shutdown.

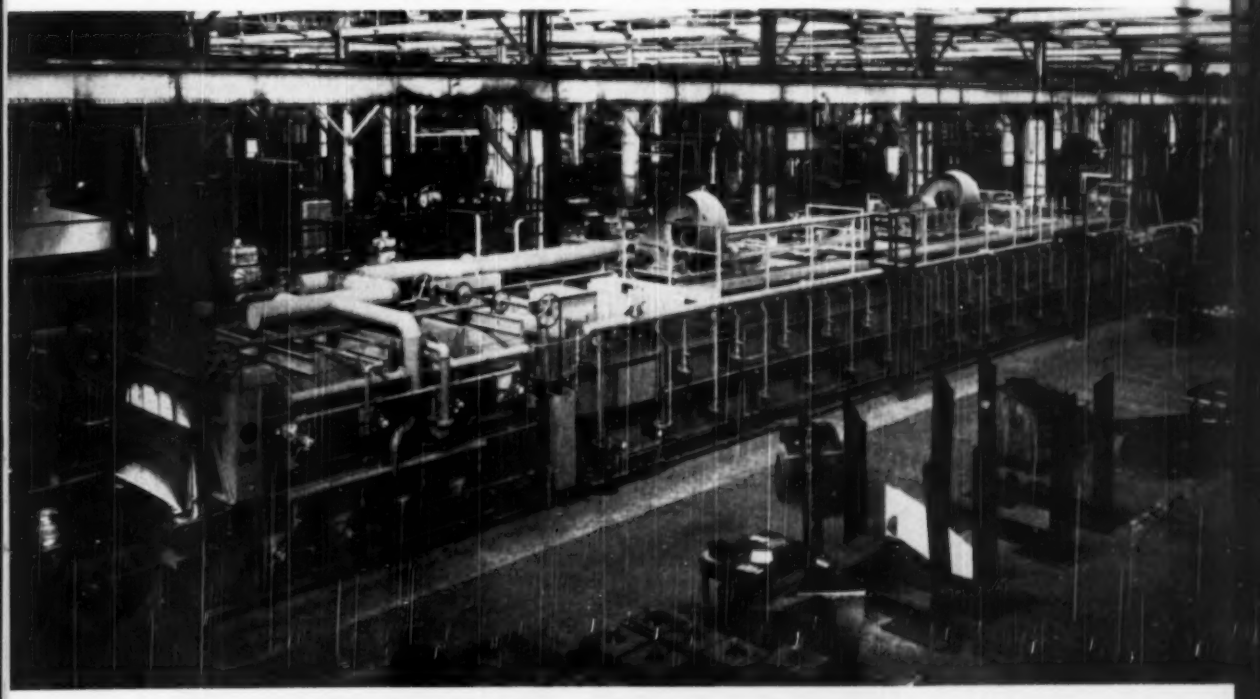
Quenching Chamber — Several new ideas are incorporated in the 15-ft. quenching chamber (right end of Fig. 1), constructed entirely of stainless steel. The advancing bars are hit top and bottom by a series of ten water jets, then from sprays, and lastly flooded from an upper trough — a final device that condenses much of the vaporized steam and also effectively seals the exit slot. Exit temperature of the bars is 100° F. in winter when make-up water is at 70° F., and is 130° F. in summer when make-up water is at 95° F. Sump water is recirculated continuously by centrifugal pump to the jets and water curtain; make-up water from the plant system flows through the water jacket and then is pumped through the spray nozzles. The quench-chamber not only saves much floor space otherwise required for cooling tables, but also delivers stock with a minimum of scale.

Long Bar Annealer

From the flow sheet of Scovill's continuous strip mill published in *Metal Progress* last month (p. 198) it can be seen that the cast slabs are cold rolled on a two-high mill in circuit with the "short bar" annealer described in the preceding paragraphs. After the final series of passes brings the slab down to about 0.40 in., it passes directly on to a "long bar" annealer, and thence to an overhauler (surface miller), when it is ready for the four-high rundown mill.

This long bar annealer, engineered and built by Surface Combustion Corp., is sectionalized much

Fig. 2 — Short Bar Annealing Furnace (Open-Muffle, Continuous, Roller-Hearth Type). Passage of metal is from left to right. Note staggered position of burners, making for uniform heat distribution and ease of temperature control. Fans on roof are for combustion air. Propane gas is fuel



like the short bar annealer, already described in detail, in that it has a preheating section 14 ft. long, a soaking section 71 ft. long, an unfired vestibule or "slow cooling" zone 4 ft. long, and a stainless steel quenching tank 12 ft. long. Capacity is also 36,700 lb. per hr. of ingot bar, since the entire mill production must be treated. Inside, the furnace is 4 in. wider than the short bar annealer; work travel pattern is two or three parallel rows of bars, one or two-high. Maximum design temperature is 1475° F. (800° C.) although bars are ordinarily treated to 1380° F. (750° C.) max. Hearth speed can be varied between 1.8 and 7.8 ft. per min.

The preheat chamber is fired by special refractory-tip tunnel burners, 12 through each sidewall, staggered alternately above and below the conveyer line. They are grouped in an efficient pattern in the forward half of the chamber. Combustion gases then sweep against the motion of the bars toward the entrance door (where both roof and hearth are constricted for a distance of 4 ft.) and are exhausted through a series of ports through the arch into an exhaust system. The burners will handle either propane gas or fuel oil.

Passing on from the preheat zone the bars enter the 71-ft. soaking zone. It is heated by 72 low-pressure propane burners, alternately placed above and below the work (36 in either sidewall). These burners are of the automatic proportioning velocity type, and are divided into six zones for operation, as will be described below. Annealing temperatures can be varied by adjusting the burners in the preheating section rather than in the long soaking section.

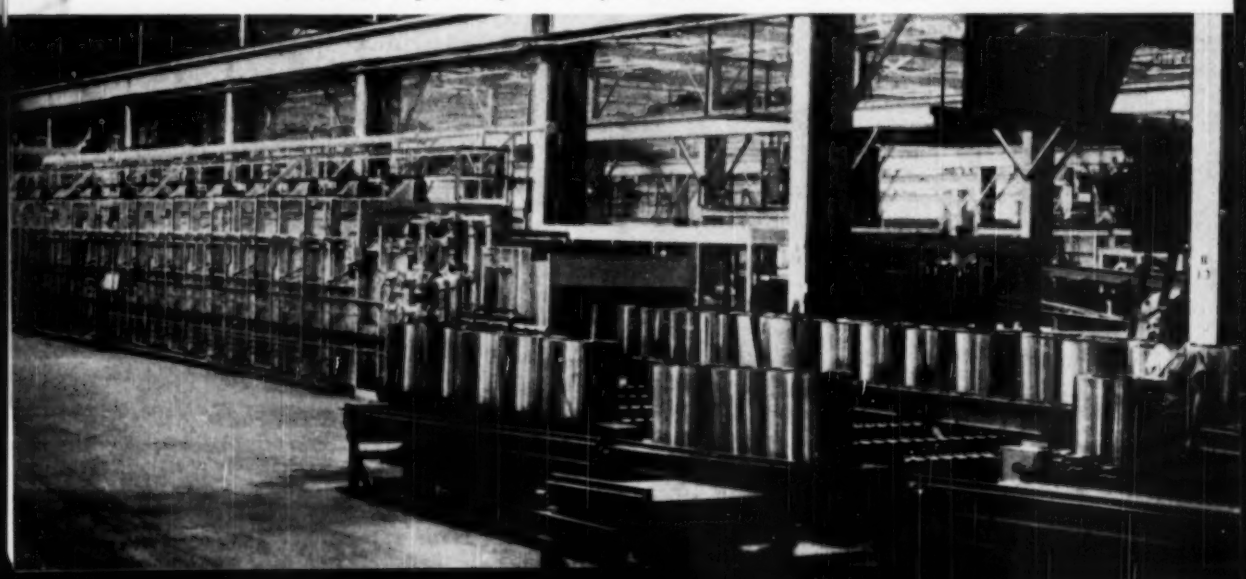
The conveyer rollers are air cooled, and made of heat resisting alloy. (In the quench chamber they are of brass, water cooled. The hearth line in the slow cooling zone also slopes downward slightly toward the exit, to avoid the possibility that water will travel backward on top of the bars and get into the furnace proper.) Rollers are set on 8-in. centers; each one is chain-driven through one countershaft drive running the entire length.

Coil Annealers

Product of the four-high rundown mill and the four-high finishing mill is in coil form, and each mill is served by a coil annealing furnace and a continuous cleaning and pickling unit. It is believed by the furnace makers, Surface Combustion Corp., that the two furnaces (substantially alike in construction) are the world's largest continuous annealing units for nonferrous metals. The coils to be handled are 16 to 24 in. high, 23 to 30 in. in outside diameter, and may weigh up to one ton. The furnace has door slots and other vertical clearances of 37.5 in. above the hearth line. Work travel pattern is two parallel single rows of coils, standing on edge (Fig. 3).

Because of the weight requirements encountered in continuous brass annealing, a fully loaded furnace holds as much as 250,000 lb. of sheet stock. The power rollers used in the heating chamber are therefore fabricated of seamless alloy tubing with a rated carrying capacity in bending of 2000 lb. per roll at 1475° F. (800° C.) and 5700 lb. at 500° F. (260° C.). These rolls are on 10-in. centers and provide a work width up to 5 ft.

Fig. 3 — Discharge End of One of the Coil Annealing Furnaces. Double row of coils is emerging from quench chamber. Two furnaces of this sort were built by Surface Combustion Corp.; one is for coils only; the one shown will handle either bars or coils



The 100-ft. heating chamber in these furnaces is further divided into five heat zones for ready adjustment of heating cycles. Furnace temperatures can be changed for different alloys by merely leaving an empty zone between successive charges, thus eliminating the necessity for resorting to the costly and time-consuming operation of clearing the entire furnace. Each heat zone is controlled by indicating and recording instruments of the potentiometer type, separately limited to a temperature that is a few degrees above a main controller instrument setting. This prevents the furnaces from overheating in the event this main controller fails.

The burner equipment consists of 92 Surface Combustion low-pressure, automatic proportioning, velocity-type burners operating on propane gas. Each burner is equipped with a premix continuous burning pilot. They are located in the sidewalls and are staggered to fire above and below the work.

With the furnace at operating temperature, in equilibrium, and annealing at the rated capacity of 32,500 lb. per hr. of coiled stock, the coils have an actual soaking period of at least 30 min. The metal temperature in any part of a coil or even coil to coil will not vary more than ±10° F. Also, the controlled furnace temperature in all zones does not exceed final metal temperature by more than 20° F.

To realize this even distribution of heated gases through the charge, especially during the annealing of sheet coils, 13 recirculating fans are situated just under the furnace arch. The fan bearings are water cooled, have 36-in. blades and are driven by individual 3-hp. motors with separate push-button controls. Such efficient recirculating of gas in a continuous furnace permits almost any desired heating cycle. The operator can bring the work to temperature at discharge, or soak for periods ranging from minutes to hours, or from 10% to 50% of the furnace length, depending on production requirements and on the type of alloy and size of material being processed.

Numerous safety devices are incorporated for insurance against costly shutdowns and possible loss of material from overheating. All burners shut off if the rollers in any part of the furnace stop; all drives are protected by shear pins and limit switches to prevent overloads and jams; burners automatically shut down if there should be a utility failure. Strategically located indicator lights assist the furnace operator to locate each source of trouble.

Prepared atmosphere is used in none of these furnaces in Scovill's new mill. True "bright" annealing of copper alloys containing more than about 5% zinc is very difficult, since enough of the zinc vaporizes at the annealing temperature to produce a slightly frosty surface. Consequently, the general practice in American industry (except for the very finest wire and thinnest gages) is to "clean anneal" the slightly oversized material, pickle, and then smooth the surface and bring to gage in a final pass through cold rolls with superfinished surfaces. Such "clean annealing" is done in open-muffle or direct-fired furnaces wherein the combustion is carefully controlled as to gas-air ratio, and wherein most of the copper-base alloys are safely exposed to the flue gases.

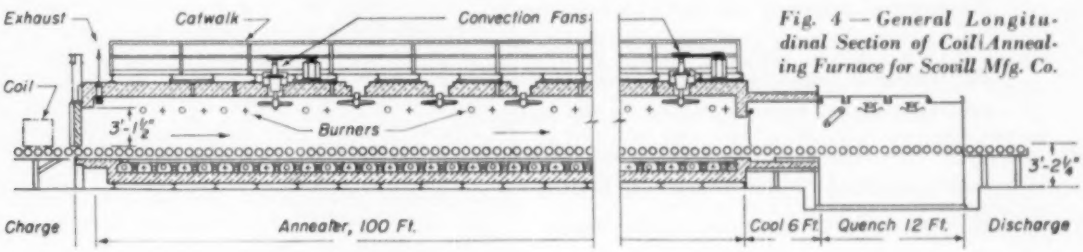


Fig. 4 — General Longitudinal Section of Coil Annealing Furnace for Scovill Mfg. Co.

Conclusion

The high production schedules planned for this notable brass mill dictated the need for nonferrous annealing facilities capable of speed, adaptability, and reliability. Direct-fired roller-hearth types of gas furnace (with water spray quench) were chosen because of fuel economy, minimum floor space, and adaptability to high and low production rates and to various alloys and tempers. The addition of forced convection fans in the coil annealers increased the efficiency of the basic design. Their dependability and versatile production characteristics are largely responsible for the good drawing qualities and uniform color and hardness, characteristic of the brass sheet produced by this new mill.

Modern Heat Treating

I—The Salt Bath

By William Adam, Jr.
Vice-President
and Leon B. Rosseau
Assistant Vice-President
Ajax Electric Co., Philadelphia

Phenomenal growth of salt baths for heat treating has resulted from a revolutionary change in the method of heating the bath and a series of improvements in the composition of the baths themselves. This brief article listing their advantages (and disadvantages, as well) will be followed by others considering their actual operation.

IN A SERIES of short papers we will attempt to evaluate both the merits and shortcomings of salt baths. Such an attempt is warranted, since the perfect heat treating process has yet to make its appearance and most likely never will; therefore, the choice of furnace equipment becomes a matter of marshaling the respective performance features of competitive heating processes and determining their relative importance for the job at hand.

The modern electric salt bath furnace is a comparatively recent development. It was introduced to industry about 14 years ago and during that period some 3000 installations have been made with a connected load exceeding 200,000 kw. Concurrently the manufacturers of heat treating salts contributed many noteworthy improvements affecting the chemical balance, control, rectification and economy of the various compounds. In consequence, the electrically heated salt bath is today one of the recognized tools available not only for the heat treatment of metals, but also to other industries for processes unknown a few years ago.

Although the salt bath is not a panacea, nevertheless the remarkable increase in its use must have some solid foundations. Therefore, an understanding of these basic characteristics is essential in order to evaluate the data presented in these articles. These are:

1. Surface Protection — All work immersed in molten salt is automatically protected from contact with air, not only while in the bath, but also after removal from the bath until quenched. It is an automatic protection secured without special equipment and at the cost only of the "drag-out" — the salt film covering the surface of the hot work.

2. Automatic Preheat — Due to the high melting point of most salts, a cocoon of frozen salt forms on the surface of the cold work immediately when introduced in the bath. This frozen salt is a poor conductor and retards the initial rate of heating until the surface of the work reaches a temperature approaching the melting point of the salt. Therefore, the heat shock sustained in the initial heating on a piece with varying section is drastically reduced.

3. Uniformity of Heating — Liquid salt surrounds the work and transmits heat to all surfaces simultaneously. There is no "shading" effect.

4. Rapid Heating — The rate of heating depends on the conductivity of the metal itself. A salt bath will heat work at least four times faster than a furnace utilizing radiant heat and operating at the same temperature. For example, a 1-in. round steel bar can be heated uniformly to 1500° F. in slightly more than 3 min. in a salt bath.

5. Buoyancy — Molten salts have a density ranging from one and one half to three times that of water. While all common metals readily sink in molten salt, they are nevertheless supported to a considerable degree by the buoyancy. A 10-lb. piece immersed in a neutral chloride bath weighs

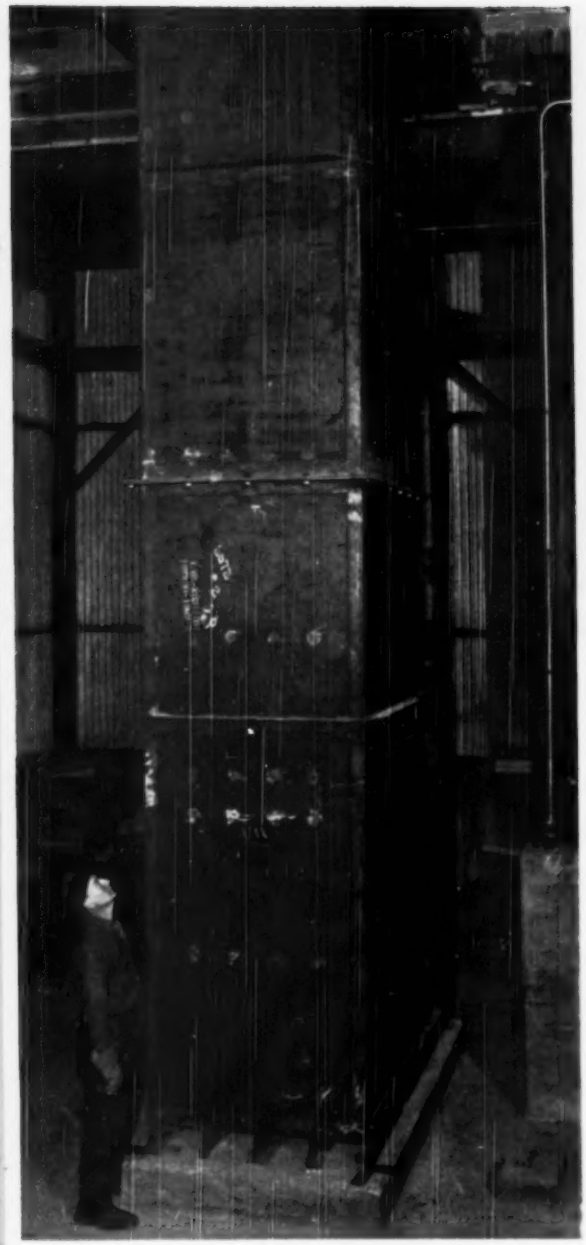


Fig. 1 — Submerged Electrode Furnace for Brazing Aluminum Heat Exchangers Has a Bath With Working Dimensions of 15 In. by 18 In. by 21 Ft. It has four pairs of submerged electrodes. A complete outer steel casing prevents salt leakage

only 6 lb. Therefore, the distortion or warpage hazard is reduced.

There are, however, some undesirable characteristics of the salt baths generally which must be taken into account:

1. Limited Range — There is no single salt covering the entire temperature range, and the use of a furnace is therefore limited to the working range of the bath it contains. Most salt mixtures have a useful working range of about 600° F.

2. Work Shape Limitations — There are shapes which cannot be satisfactorily treated in salt, either because they will float or because they will drag out an excessive amount of salt.

3. Dryness — All work must be dry, otherwise a violent reaction occurs due to the sudden generation of steam.

Method of Heating the Bath

There are two general types of electric salt bath furnaces, the externally heated and the internally heated. Our discussion will be limited to the internally heated design because of its many advantages and its much wider field of application. In this type the container has only one duty to perform, namely, to hold the bath. Its temperature is only that of the bath itself; it need not be metallic since no heat is conducted through its walls. Two designs of the internally heated salt bath are in common use:

1. Immersion Heater Design — The heaters are resistance elements encased in tubes of suitable metals, and are formed to suit the shape of the pot. This construction can be used from 300 to 1000° F. (but seldom above 750° F.). It is quite inexpensive to build, is very efficient and has been widely adopted in the low-temperature field.

2. Immersed Electrode Design — The electrode design depends on the fact that the molten salts used for heat treating are relatively good electrical conductors. Current passes through the bath between heavy metallic electrodes, so that the heat is generated directly within the bath. Electrodes are closely spaced in pairs to produce electromagnetic conditions between them which in turn create electrodynamic forces producing an automatic stirring action throughout the entire bath. Liquid salt is drawn into the gap between the electrodes and sucked downward — exactly opposite to the flow that might be obtained by thermal convection. This extremely active circulation literally takes the heat away from the electrode area as fast as it is generated — so quickly, in fact, that there is no measurable temperature gradient between the main body of the bath and the electrode area.

An electrode furnace must operate from alternating current supply to avoid electrolysis (disintegration) of the salt. It always uses a step-down transformer to give the necessary range of low secondary voltages — 5 to 20 volts, depending on conditions. This type of furnace can be designed for any temperature from 350 to 2400° F.

The generation of heat directly in the salt permits great latitude in designing the shape of pot. For many installations, ceramic pots are used which have extremely long life (measured in years). Size and shape of the furnace are practically unlimited. Furnaces are in operation today with a bath 40 ft. long, 8 ft. wide, and more than 20 ft. deep — although no single unit has all these extreme dimensions. Where the depth is 6 ft. or less, electrodes are mounted on one level, normally entering from the top. Deeper furnaces have submerged electrodes in pairs, one above the other, to assure uniform temperature distribution and facilitate remelting of a solidified bath. Figure 1 shows a vertical furnace, 21 ft. deep for brazing heat exchangers; Fig. 2 is a diagram of the internal arrangement of a shorter pot.

In deep furnaces of this type, the work is loaded vertically, and the cross section of the bath will, therefore, be small, while its depth will be great. The only way in which adequate power may be introduced in the furnace requiring multiple pairs of electrodes is to build these through the walls of the furnace, sealing them adequately against salt leaks by water cooling that portion of the electrode coming out of the furnace casing. Location of electrode sets, one above the other, avoids all difficulty in starting or restarting a unit.

Should the bath freeze due to a plant shutdown, a power failure, or the malfunctioning of the control equipment, the furnace can be restarted easily. The top pair of electrodes are high enough so that the salt's shrinkage upon freezing exposes the top of the electrodes, as shown by the dotted line in Fig. 2, thus permitting the bath to be melted as easily as with the ordinary suspended electrode design. After the top zone is melted, liquid salt is presented to the next lower tier of electrodes which are then switched on and in turn melt the salt in that zone. This procedure continues until the entire bath is melted. This scheme of melting from the top downward prevents any pressure buildup at the bottom of the furnace which could readily cause trouble if the top were still solid.

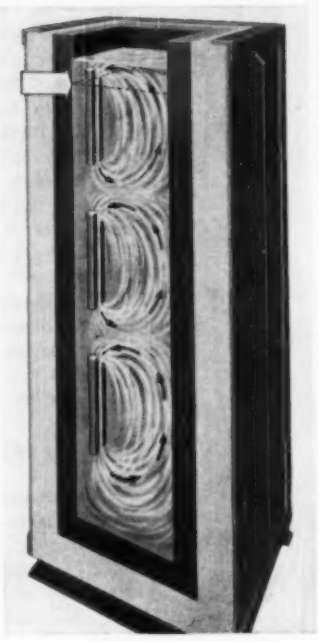


Fig. 2 — Cross-Sectional Diagram of Deep Submerged Electrode Furnace Having Three Pairs of Closely-Spaced Vertical Electrodes, Cascaded for Ease of Restarting. Arrows show electrodynamic circulation which assures uniform bath temperature

The photo in Fig. 1 shows an installation of the submerged electrode design, the bath having effective working dimensions of 15 in. by 18 in. by 21 ft. It contains four pairs of electrodes giving the furnace an input of 100 kw. Notice that a conventional steel shell is used to withstand the considerable hydrostatic pressure created at the bottom by such a high column of salt and to prevent any danger from leaks.

This type of furnace is used where vertical loading of the work is either necessary or of great advantage. Despite the high thermal efficiency of this construction (produced by the small area of exposed bath) difficulties in fixturing the work and quenching indicate a preference for the conventional design — namely, the longer and shallower baths — for heat treating articles of normal size.

Reasons for Success

In summary, the salt bath furnace has come to the fore as one of the popular tools for the heat treater because of the economies it provides. These, in the main, are the results of the following factors:

1. High productive capacity per unit of floor space.
2. Protection of the surface of the work.
3. Definitely reduced distortion.
4. Low investment per unit of production.
5. Elimination of skilled labor.
6. Long life and reasonable maintenance.

EDITOR'S NOTE: Subsequent articles will discuss various operations performed in modern metallurgical shops with the aid of salt baths.

Critical Points

By The Editors

THE SUBJECT of evaluating mechanical tests recurs several times in this issue of *Metal Progress*. Any inquiry into the usefulness of tests must start with the question — usefulness for whom? Answers vary. Thus: A. L. BOEGEHOLD's article "Test Bar Results Compared With Tests on Components", starting on p. 349, speaks authoritatively about automotive parts made from heat treated steel; but the opinions of one concerned with ship structures have a different emphasis (p. 368). Responses to a questionnaire sent out by a Russian technical journal (reviewed on p. 358) represent the diverse — even perverse — attitudes of nine Soviet engineers; while CARL BENEDICKS, well-known Swedish scientist, has an eye single to the fundamental mechanical properties of metals (p. 407) . . . . By and large, engineers are not well satisfied with present-day mechanical tests, despite the extent to which they are relied upon in purchase specifications. Tensile strength and percentage elongation, for instance, are much beloved by specification writers, but have been of slight value to the designer or fabricator of machine parts. Consider automotive and aircraft engines: These have long been subjected to *service* tests wherein a component of questionable design is built into a full-size engine, all personnel removed to a safe distance, and the engine run a certain time at high speed and high load. This routine has been called the "bushel basket method", in honor of the receptacle into which broken pieces are retrieved when a doubtful component fails! Because of the lack of helpful information obtained — and high cost — such "service" tests have been partly replaced by simulated service tests on fully fabricated components or simple assemblies, without the complete machine or structure. . . . . All the while, of course, the mathematical analysts have been trying to calculate the stress distribution for various loads and shapes; more recently the electric strain gage, brittle lacquer and photo-elastic techniques have made possible a concentrated experimental attack with such success as to inspire W. T. BEAN to formulate the quantitative conclusion that one can of brittle lacquer is worth six mathematicians.

Evaluating mechanical tests

ALONG with the surge of activity among experimental stress analysts has come a closer attention to a particularly difficult kind of stress, termed "residual stress" — for example, that left over from heat treatment. In dealing with this residue, the metallurgist is not merely helpful but indispensable because no other engineer has the detailed knowledge of the structure of metals that is required for understanding the origin of residual stresses. This is especially true for steel parts, in which they are closely related to hardenability; in fact, Mr. BOEGEHOLD suggests that variation of residual stress is the most serious consequence of hardenability variation with the H-band. This suggestion deserves thorough exploration. Also, systematic information is needed on the influence of size and quenching rate. There are also lessons to be learned about the effects of tempering, the first requisite being to abandon the idea that tempering always improves the pattern of residual stresses. These and other questions about stresses are among the foremost of present challenges to the metallurgist. By answering them, he will further enlarge his influence on design and fabrication procedures.

Residual stresses

ONE OFTEN WONDERS about the seeming stability of an ancient process. For example, it is hard to believe that the potter's wheel is so like its early ancestor because it is so exactly fitted to its duty. Is the art of bricklaying stabilized because of perfection, because the bricklayers are conservatively content to do as their fathers did, or because the trade is tightly unionized? Or for some other reason? Looking closer home one finds that in some metallurgical operations, at least, tradition has been demolished. Wire drawing is an example: Originally, stubby lengths were pulled through dies by hand. Then the tongs were hooked to water wheels. Eventually draw benches with power

Fast work at the draw bench

reels were devised, but always the speed of drawing was low — any speedup would probably be held to lower the quality of the wire. THE EDITOR well remembers his youthful surprise in seeing fine copper wire drawn at extraordinary speeds — an innovation of DAVID LEVINGER at Hawthorne Works of Western Electric Co. that brought him substantial promotion and brought Americans cheaper telephone cable. Another quite recent example applies to the drawing of copper tubes (an item now of large importance for water lines in residences and commercial buildings). Conventional draw benches are loaded singly, by hand, and chain-pulled tongs draw the tube through the die at a leisurely pace — say 100 ft. per min. — with a skilled workman constantly standing by. A new bench observed by THE EDITOR at a tube mill which desires to remain anonymous has at least ten times this capacity and requires only one attendant. Three tubes are automatically placed in front of a three-hole die plate, thrust through, and all of them seized by a gripper-jaw draw carriage hooked to a chain traveling at a rapid walk — about four miles an hour or 400 ft. per min. The only delay is in reversing the chain and bringing the carriage back to the die; this might be avoided by arranging a duplicate that returns on a switchback while its partner is working. (The feed mechanism is now in duplicate — one unit reloads while the other is in place.) As to the limiting speed of drawing, it might possibly be anything up to the ability to cool the die (and any internal mandrel) so they won't expand enough from frictional heat to throw the tube's wall or diameter off specification.

We may start again from protozoa

IN THE 7TH Report of the U. S. Atomic Energy Commission to Congress it is remarked in the section on biology and medicine that "many lower forms of life, such as plankton (which include many forms from protozoa to jellyfish) tolerate very high levels of fission radioactive material". Obvious, my dear Watson — once granted that natural radioactivity is continually decaying. The simplest cells could not be born in early geologic time until they could live amidst comparatively intense radioactivity. Mere man had to wait until this cosmic clock had run down to levels he could safely endure — only yesterday, pre-Hiroshima, in fact.

Correspondence

Uranium as a Metallographic Aid

BRECKSVILLE, OHIO

It is well known to microscopists using the electron microscope for surface studies that detail on the photographic plate is likely to be very dim when the object under observation is a light metal or a compound of hydrogen, carbon and oxygen. However, if one sprays the sample [or replica] in a vacuum, with a stream of heavy metal atoms, directed from an oblique angle, a very striking effect is obtained. The particles or irregularities on the object's surface become coated on one side with the thinnest film of metal, while the areas on the opposite side receive no coating. Hence deep shadows appear on the final photograph.*

Besides greatly increasing the contrast of the images, this gives an interesting three-dimensional appearance, and thus makes it much easier to interpret the result. A close analogy is noted in contrasting the flat appearance of the ground when viewed from a high-flying airplane at noon with the deep three-dimensional appearance of the landscape just before sundown when the hills, trees, and houses cast long shadows.

This technique was pioneered at the University of Michigan but it has been widely used at our Research Center and elsewhere during recent years. Heretofore, chromium has been used by us for "shadow casting", but now that uranium is available on license from the Atomic Energy Commission, it has been substituted. In order that the objects under examination suffer a minimum amount of distortion it is imperative that the metal layer be as thin as possible. On account of its high atomic number and great density, uranium is the best material for this job.

E. H. ROWE
B. F. Goodrich Research Center

*[For examples, see p. 341 to 344 of this issue.]

Pretreatment of Aluminum Sheet

CORRECTION: In the footnote on p. 825 of the December issue 0.4% $AlPO_2$ should read 0.4% AlF_3. It also should have been emphasized that the treated parts in the drying oven should not get beyond 150° F.

Bright Field, Prism Illuminator | Polarized Light, Prism Illuminator | Bright Field, Glass Slip Illuminator

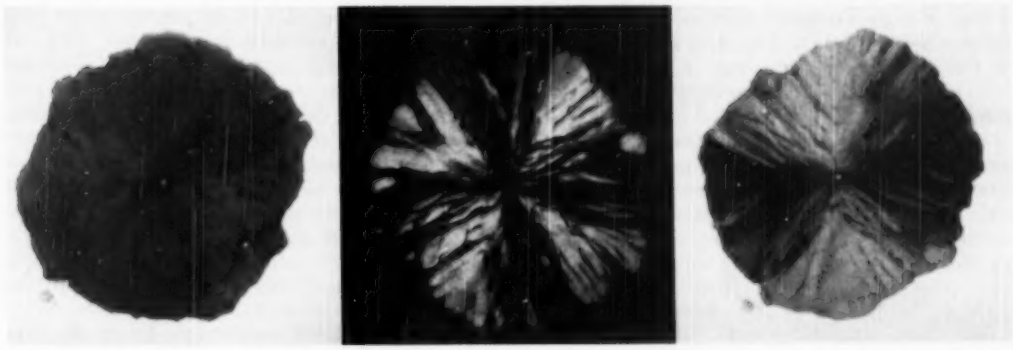


Fig. 1 to 3 — Micrographs of the Same Graphite Nodule in an Experimental Magnesium-Treated Cast Iron. 750×

Radial Structure of Graphite Nodules

SYDNEY, AUSTRALIA

In view of the current interest in nodular cast irons, it is perhaps pertinent to point out that the radial structure of nodules observed with microscopes fitted with glass slip [plane glass] illuminators is developed by the polarized portion of the incident light; light reflected from the glass slip illuminator is partly polarized in the plane of the glass slip. H. Morrogh (*Journal*, Iron & Steel Institute, Vol. 143, 1941, p. 195) has previously illustrated this principle as it applies to normal flake graphite but the features are much more marked in nodular graphite, as shown above.

The micrograph that was taken in completely unpolarized bright-field illumination from a Foster prism illuminator shows only faint evidence of a radial structure (Fig. 1), whereas fully polarized light from this prism develops a very marked radial structure (Fig. 2). Microscopes fitted with the more usual glass slip illuminator develop a radial structure intermediate between the two (Fig. 3).

M. HATHERLY AND L. E. SAMUELS
Metallurgists
Defense Research Laboratories

Identifying Ball Anodes

WEST SPRINGFIELD, MASS.

Because of the similarity in color of cadmium and zinc ball anodes, platers sometimes confuse one for the other, with consequent ruination of a batch of work. The following simple test may be carried out in the shop and requires only a small beaker, nitric acid and sodium hydroxide: Place a tiny fragment of the anode in the beaker and add a few drops of 50% nitric acid solution. If necessary, warm with a match to complete solution. Add a few drops of water and then an excess of sodium hydroxide solution. Zinc hydroxide redissolves in an excess of the sodium hydroxide while cadmium hydroxide (white precipitate) does not. Should the ball anode be tin there will be a white precipitate of tin oxide upon solution in the nitric acid. The test is rapid, inexpensive and clear-cut and avoids the unpleasantness of using hydrogen sulphide or the necessity of a laboratory check.

C. GOLDBERG
Chemist-Metallurgist
New England Smelting Works, Inc.

Testing Adhesion in Glass-Metal Seals

COVENTRY, ENGLAND

During the last ten years there has been an increasing demand for electrical components to be manufactured incorporating the use of glass-to-metal seals. Such equipment includes the modern radio valves, cathode ray tubes, and several types of high-vacuum equipment. During this development period, glass manufacturers produced several new types of glass, many of which revealed peculiar properties on sealing to metals of the low-expansion type, such as "Fernico" and "Kovar". In order to determine the quality of the adhesion between any glass and a suitable alloy, the following simple and rapid test was devised:

A bead of the glass under investigation is welded onto a length of wire or rod of the metal with which it is desired a seal should be made. This test piece is now subjected to a tensile stress in any tensile testing machine. Application of the

load causes elongation of the wire together with a reduction in cross-sectional area. If the adhesion is poor, the glass-to-metal interfaces will separate and the bead will be free to slide along the wire; on the other hand, if the seal is good the bead will crack, and the fragmented particles will remain attached to the wire.

Although the test is only qualitative, additional conditions of test can be arranged to simulate conditions known to exist in the component during use. For example, the test can be carried out with current flowing through the wire, or by maintaining the assembly at an elevated temperature.

NORMAN ALLEN
Metallurgist
A. C. Wickman, Ltd.

Prefabricated Aluminum Houses

LONDON, ENGLAND

Secondary aluminum alloys, originally obtained from the accumulation of scrap material salvaged from German aircraft destroyed over Britain, form the basic material used in the manufacture of prefabricated houses at Gloucestershire, England. An average of 160 of these "Hawksley houses" have been produced per week, the main assembly line being 800 ft. long, possibly the largest house production line in the world. The houses are made in four units, leaving the works complete with built-in cupboards and all electrical fittings. There is a main living room, two bedrooms, kitchen, bathroom and hall, giving an over-all size of 30 x 22½ x 10½ ft. The rooms are 7½ ft. to the ceiling.

The first stage of fabrication is the preparation of walls and partitions, 14 types of wall panels being required, with 13 types of partitions. The frames for these are built up from aluminum rolled sections and extrusions which are assembled in jigs of a similar pattern to those used in aircraft manufacture, and are joined together with "pop" rivets of standard aircraft type. External facings of 20-s.w.g. [0.036 in.] aluminum sheet are pop-riveted to the wall frames, and sheets of ¼-in. plasterboard to the partitions; 18-gage corrugated aluminum alloy sheet is used for the roof. Before assembly, all small metal parts are sprayed on a conveyer which takes them through an infrared oven where the drying time is a little under 10 min.

A feature of the houses is the use of lightweight foamed cement in the external walls. Cement is automatically weighed, mixed with the required proportions of calcium chloride, water and foaming agents and fed into the walls. The panels are dried in continuous kilns, 190 ft. long, the temperature rising slowly to 300° F. The resultant foamed cement is an efficient insulating medium, and tests have shown that a 3¼-in. thickness of cement prepared in this way is equivalent in insulating properties to a 14-in. brick wall. Other models utilize fiber glass insulation. Meanwhile, floors are made from a strong framework of deep section aluminum alloy girders to which are bolted standard wooden joists. Across these are nailed ⅞-in. floor boards. The roof is constructed of trusses of rolled and extruded aluminum alloy sections, riveted to purlins of similar metal, after which the skin of corrugated aluminum alloy sheet is riveted in place. Insulating boards are attached to the underside of the skin before the plasterboard ceiling panels are attached. Foundations required on site consist of flat concrete slabs, and less than two hours is required to erect the houses after delivery. After this, the furniture can be moved in immediately and the housewife can prepare a much-needed cup of tea.

TOM BISHOP
Editor, *Metal Treatment*

Metal Cleaning Problems and Tests for Cleaners

By Adolph Bregman
Consulting Editor for Metal Progress
Consulting Engineer
New York City

A PREVIOUS article on the elements of cleaning (*Metal Progress* for January) briefly discussed the main types of cleaning methods that are in use among fabricators. The purpose of this second article will be to deal more specifically with some of the cleaning methods and to survey the numerous tests employed for evaluating the effectiveness of cleaners.

One class of metals requires special consideration, namely, those that are attacked in varying degrees by the common alkaline detergents. Among these metals are tin, lead, aluminum, zinc, copper, and the alloys based on each. With such nonferrous metals it may be necessary to use the milder alkalis such as trisodium phosphate or cleaners in which the etching action is inhibited by sodium silicate with or without additional inhibitors such as sodium sulphite. The solubilized solvent cleaners and their water emulsions will serve well as soaks for preliminary cleaning, to remove heavy deposits of buffing compound or other solids, in order to reduce the time in the final cleaning solution.

Zinc-base die castings should have the bulk of the soil removed in a solvent degreaser or an emulsion cleaner soak or spray to reduce the duration of contact with the alkaline cleaner and to prevent deep etching. *Do not overclean.*

Aluminum parts to be anodized usually require a short etch where high finish or close dimensional tolerances are unnecessary. Mild alkali mixtures containing soda ash, trisodium phosphate and caustic soda can be used in 4 to 8-oz. concentrations. The etch should be followed by a dip in 5% nitric acid to remove the black film that is formed by the etching bath.

Lead is proverbially difficult to clean. However, a tried and effective method for preparing lead and lead-base alloys for subsequent plating is as follows: *(a)* degrease, *(b)* clean cathodically in a mixture of 1 oz. soda ash, 1 oz. trisodium phosphate, for a few seconds only *(do not overclean)*, *(c)* rinse, *(d)* if necessary, scrub with pumice to remove the smut or film, *(e)* rinse, *(f)* pickle in 10% fluoboric acid for about 15 sec., *(g)* rinse, and *(h)* plate.

Cleaning for Spot Welding Aluminum

Aluminum to be spot welded must be cleaned of all surface contaminants such as paint, oil and oxide film. Heavy oil films are removed by vapor degreasing. Very light oil films can be removed in a soak tank (with or without agitation) using a light-duty cleaner for aluminum, containing sodium bisulphate; or mixtures of sodium bisulphate and chromic acid; or caustic soda, trisodium phosphate and soda ash.

If a silicate-base precleaner is used, it should be followed by a thorough rinse in warm water before the use of an acid-type deoxidizer. Silicates and acids form insoluble silicic acid which dries to silica dust on the surface of seemingly clean aluminum.

To remove the oxide film, the cleaning is followed by a deoxidizer of acid or alkaline nature, depending on the particular aluminum alloy that is being spot welded.

The concentration of the cleaner solution can be controlled by conventional laboratory methods of chemical analysis, determining the free acid or alkali present. Concentration alone, however, is an insufficient index of the effectiveness of a cleaner. A very useful control is the measurement of the surface resistance of the material after cleaning. Such resistances should average within 10 microhms of each other from day to day and the over-all average should be below 50 microhms,

for sound, consistent welds. When small changes in concentration result in wide variations in surface resistance and welds vary in effectiveness, the solution is probably spent and should be replaced.

The number of cleaners for aluminum spot welding is large, the composition varying with the alloys to be welded. Among these cleaners are the following:

Sodium bisulphate 4 to 6 oz. per gal.; 0.2% "Nacconal NR".

Sodium bisulphate 85 to 90%; chromic acid 15 to 10%; 14 to 16 oz. of mixture per gal. of solution.

Caustic soda 10 to 15%; trisodium phosphate 10 to 15%; soda ash, balance; wetting agent; 4 to 6 oz. of mixture per gal.

Nitric acid 1½ to 4½ oz. per gal.

Sulphuric acid ½ to 1 oz. per gal.; 0.1% "Nacconal NR".

Hydrofluosilicic acid 1.8 to 10%; wetting agent 0.1%.

Orthophosphoric acid 40%.

Fluoboric acid 3% by weight; hydrofluoric acid 2% by volume; in water.

Boric acid 3%; sodium fluoride 1%; chromic acid 1%; wetting agent; in water.

In some solutions it has been found that the addition of 0.1% potassium dichromate to the acid deoxidizer protects the aluminum from the effect of impure rinse waters which might otherwise raise the surface resistance of the metal enough to prevent a good weld. Moreover, the final rinse before welding should be in cold water; not hot, which would cause higher resistance in a manner analogous to "sealing" after anodizing. Dry in warm air; do not wipe.

In a survey of commercial practice,* it was found that on bare 24S-T alloy, nine plants used an acidic deoxidizer, while two used an alkaline type. For deoxidizing the surface of Alclad 24S-T, ten companies reported the use of "Oakite 84A", four used hydrofluoric acid, four used "Kelite K-1", two used a hydrofluoric acid solution, two used "Diversey DC-1", three used "Oakite 30", and one used sodium hydroxide solution.

Reference is made to a solution which degreases and deoxidizes in one tank. The solution consists of phosphoric acid and "butyl cello-solve" which cleans and etches in one operation.

Among the larger airplane companies, either hydrofluosilicic acid or some proprietary product is commonly used. One large company uses a solution of 10% nitric acid and 2% sodium fluoride; another, a solution of sulphuric acid, sodium dichromate, and hydrofluoric acid; both at room temperature. In the New Kensington plant, the Aluminum Co. of America uses a cold solution made up of 12% nitric acid and 0.2% hydrofluoric acid — a solution described as being suitable for all aluminum alloys, clad and unclad.

*"Cleaning Aluminum Sheet Prior to Spot Welding", by Gerard H. Boss, *Metal Progress*, April 1949, p. 499; May 1949, p. 668.

Sodium Hydride Descaling

An important and interesting aspect of metal cleaning is the treatment of clad steel and solid stainless steel plates and sheets. In the past, this cleaning has been done by sandblasting which, while reasonably effective, has the disadvantage of leaving a comparatively rough surface. In some plants these methods have been superseded by sodium hydride cleaning or descaling. In the plant of Lukens Steel Co., Coatesville, Pa., the sodium hydride descaling process can be used on all Lukens clad steels, nickel-clad, stainless-clad, Inconel-clad and Monel-clad steels; on alloy steels and on all metals not affected adversely by molten caustic or by heating to 800° F. This process consists of a dip in a bath of molten caustic soda containing sodium hydride which reduces the metallic oxides of the scale. Most of the reduced

(Continued on p. 394)

Fig. 1 — Large Stainless-Clad Plate Going Through Sodium Hydride Descaling Plant of Lukens Steel Co.

Electron Metallography of Cemented Carbides

By William L. Grube
Physics Instrumentation Dept.
Research Laboratories Division
General Motors Corp., Detroit

HARD METAL compositions or "cemented carbides" are of metallurgical interest because of their widespread use as metal cutting tools, drawing dies, and wear resistant elements in various industrial machines. These tool and die metals are harder than the hardest toolsteel, many times more wear resistant, and have effected great economies in the metal working industries. Cemented carbides are characterized by a structure in which finely divided carbides of the refractory metals are held in a matrix of a relatively soft and less refractory metal or alloy. Tungsten carbide constitutes the major portion of these hard alloys, either alone or in conjunction with various combinations of carbides of titanium, tantalum or columbium. A metal of the iron group, usually cobalt, is present in minor proportions as the binder or cementing agent.

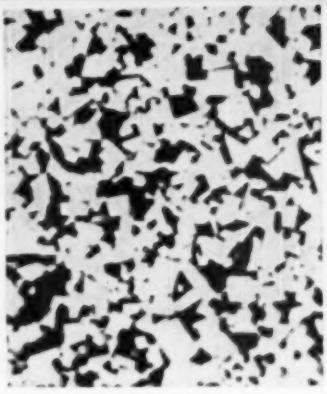
The cemented carbide compacts which eventually become the metal cutting tool or some other wear resistant device are made by processes of powder metallurgy wherein finely divided powders of the carbides are mixed or milled with fine powders of the softer binder metal. After sufficient mixing, the powders are compacted into the desired shape and sintered in a neutral or reducing atmosphere under conditions of partial melting and solution. Commercially available grades of cemented carbides made in the above manner exhibit extremely high hardness, being surpassed only by diamond, silicon carbide and boron carbide. Moreover, the cemented carbides exhibit other desirable physical properties which make their performance superior to the harder materials in many applications. Among these desirable properties are extreme stiffness, high transverse-rupture strength and high compressive strength.

Often the properties of commercial cemented carbide depend more on control in manufacture than on chemical composition. Consequently, it is difficult to predict the performance of a given tool merely by knowing the nature and proportions of its constituents. Physical tests have been devised by which the characteristics of a particular carbide can be determined but such tests suffer the disadvantage of being destructive. Granted that it must first be correlated with performance, metallographic examination is a much more convenient means for appraising quality of a cemented carbide. Such examination is useful not only in evaluating tool performance but also in controlling the processes used in producing cemented carbide.

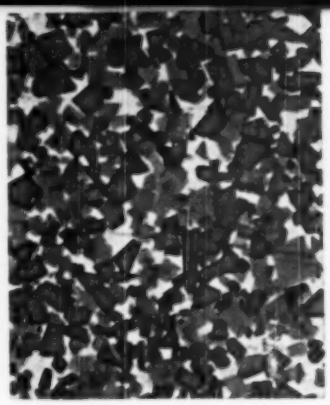
Conventional Metallography

The first of four routine metallographic examinations made of cemented carbides is the examination of polished specimens under the light microscope at 200×. Plane surfaces for this examination, as for all subsequent ones, are prepared by polishing on rotary laps impregnated with diamond abrasive compounds. For the final polish an abrasive having a maximum particle size of one micron is used. Examination of such a prepared surface at 200× reveals any inherent or apparent porosity in the finished tool. The extent of inherent porosity is a measure of the soundness of the cemented carbide. Figure 1 shows a carbide tool having appreciable porosity. The percentage porosity is estimated by comparing the micrograph with a standard chart and for the example shown is about 1%. The causes of porosity probably do not differ essentially from those resulting in similar defects in cast metals — solid and gaseous impurities, and improper furnace conditions. Milling and mixing methods or pressing techniques may also be at fault. A product free from porosity and of uniformly high density is desired, although it is becoming more and more apparent that a slight porosity is not objectionable.

As Polished, 200×



Electroleached, 1500×



Alkali-Ferricyanide Etch, 1500×

Fig. 1 to 3 — Conventional Light Micrographs of Cemented Tungsten Carbide – Cobalt Compositions

Next an "electroleached" specimen is examined at 1500×. These specimens are prepared by anodic electrolytic action in an ammonium chloride electrolyte which "leaches" out the binder metal, leaving a skeleton of the carbide phases, as shown in Fig. 2. In this micrograph the black areas are the voids remaining after dissolution of the binder metal, and the white network is the carbide skeleton. From micrographs such as this the final distribution of the binder metal can be determined — the distribution being a measure of quality of milling practice, effectiveness of the binder during sintering, and the gross bonding.

After repolishing, the microstructure is developed by an immersion etch in an alkali-ferricyanide solution (equal parts of 10% potassium hydroxide and 10% potassium ferricyanide) in preparation for the next micrographic examination, also at 1500×. As shown in Fig. 3, this etch reveals the individual grains of carbide embedded in the matrix of binder metal. These micrographs are used in the analysis of inherent grain size and in the study of its relationship to manufacturing methods and tool performance.

These applications of conventional metallography to the microstructure of cemented carbides have been useful in studying the mechanism of changes that occur in the fabrication of cemented carbide tools. They have been equally useful as an aid in predicting the performance of a particular tool. However, neither producer nor consumer can, as yet, claim a complete understanding of these sintered carbides.

Electron Metallographic Techniques

The application of electron metallographic techniques shows promise of extending the study of the metallurgical properties of cemented carbides to a point which includes all of the microstructural detail developed by chemical etchants. Electron micrographs are not only a clearer representation of the structure resolved by light systems but they exhibit detail heretofore unresolved.

The polishing procedure and the etchant used are the same as for light metallography with the exception that, for some compositions, the etching time is shorter. As in light metallography, electrolytic etching may be used.

For observing the microstructure in the electron microscope, negative replicas are employed. These replicas are cast on the etched surface from 0.75% solution of formvar in dioxane or of parlodion in amyl acetate. For studying the relief in the etched surface, the replicas may be used in the condition as stripped from the specimen. In order to increase contrast and to render smaller detail visible, the replicas are shadow-cast with chromium at arc cotangent 2 (27°) or arc cotangent 1 (45°), depending on the size and type of microstructural detail to be studied. For finer detail, the more oblique angle is used; the higher angle (45°) is employed when it is desirable to study the gross structure.

Generally, electron micrographs of replicas that have been shadowed at a high angle are direct-printed; that is, the prints are made directly from the negative plate exposed in the microscope without an intermediate photographic reversal to make actual shadows dark. The net effect of high-angle shadowing and direct printing is to make negative replicas appear as positives, insofar as relief is concerned. As a result, the correct relief of the surface of the original specimen is maintained. The first three electron micrographs to be discussed will illustrate how the shadowing and photographic techniques are varied slightly to suit the microstructural detail being investigated.

One microstructural detail of cemented carbides that can be studied by electron microscopical methods is the differential etching of the various phases present. Differential etching can be investigated conveniently with unshadowed negative replicas as shown in Fig. 4. Here is shown an electron micrograph at 7500× of an unshadowed parlodion negative replica of a simple cemented

carbide structure consisting of pure tungsten carbide grains embedded in a matrix of cobalt. An analysis of the light intensities shown indicates that the etchant used (alkali-ferricyanide) attacks the carbide phase and leaves the cobalt binder relatively undisturbed. As will be shown later, the etchant also exhibits a preferential attack on the various carbide phases present in more complicated compositions. The differential etching of simple structures must be well understood before attempting to interpret electron micrographs of the more complicated carbide structures.

Through electron metallography the study of inherent grain size and the distribution of grain size has been extended downward to include the smallest carbide grains present in cemented compositions. Measurements of grain size can be made directly from projected images of the microscope plates or from direct prints such as the one shown in Fig. 5, which is from a replica shadowed at an angle of 45°. The micrograph has been direct-printed and, therefore, the relative relief of the two constituents should appear the same as in the original specimen.

The exact distribution of the binder metal can also be studied in this electron micrograph (Fig. 5), which, as in the electroleached specimens, gives information about the gross bonding within the composition. Even more important is the intergranular bonding between adjacent grains of like composition. Since this sort of detail is on an extremely fine scale, the replicas used for this study are shadowed at a lower angle (27°). Furthermore, the micrographs are reverse-printed so as to make the "metallic" shadows dark and thus simplify interpretation of the finer detail.

As revealed at a magnification of 15,000×, the intergranular bonding of compositions consisting solely of tungsten carbide and cobalt (Fig. 6) seems to be different from that of the more complex carbides to be discussed later. The work completed thus far has been preliminary, and closer study of the grain boundary conditions must precede a more specific comparison of the intergranular bonding in various aggregates.

Performance Characteristics

Cemented carbide compositions are divided into two classes: *(a)* Those in which the hard constituent is tungsten carbide, as discussed above, and *(b)* the steel cutting grades which derive their characteristic properties and resistance to wear from hard carbide ingredients other than tungsten carbide. The first type is used chiefly for dies, for machining nonferrous metals and for machining cast irons or other materials which form small, crumbly chips. For machining steel, however, the straight tungsten carbide tools are unsatisfactory because of their lack of resistance to a particular form of tool wear called "cratering", on the tool tip back of the cutting edge where the pressure of the chip is greatest.

This cratering action is due to the "welding on" of the chip to the tool tip strongly enough to pull out the tungsten carbide grains. Incorporation of refractory metal carbides other than tungsten carbide in the composition results in a tool material which resists cratering. Titanium carbide in conjunction with tungsten carbide has had the most widespread use in the steel cutting grades but tantalum and columbium carbides may also be used, as well as various combinations of all of them. Such combinations result in the formation of a complex carbide phase or a multicomponent solid solution.

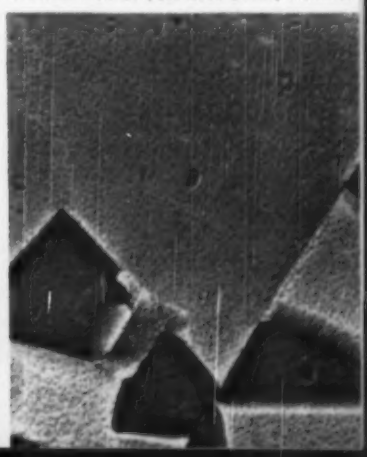
When a particular machining problem arises, each carbide manufacturer may recommend a certain grade designed for the application. Although recommended for the same machining operation, grades from different manufacturers may differ considerably in tool performance. For

Fig. 4 to 6 — Electron Micrographs of Cemented Tungsten Carbide – Cobalt Compositions

Parlodion Negative Replica, 7500×

Cr-Shadowed 45°, Direct Print, 7500×

Cr-Shadowed 27°, Reverse Print, 15,000×



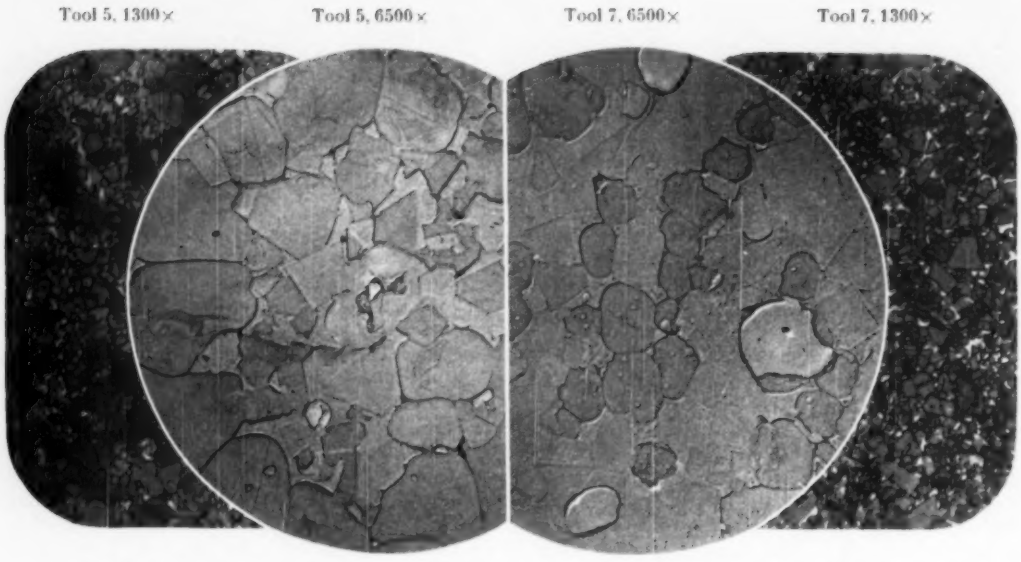


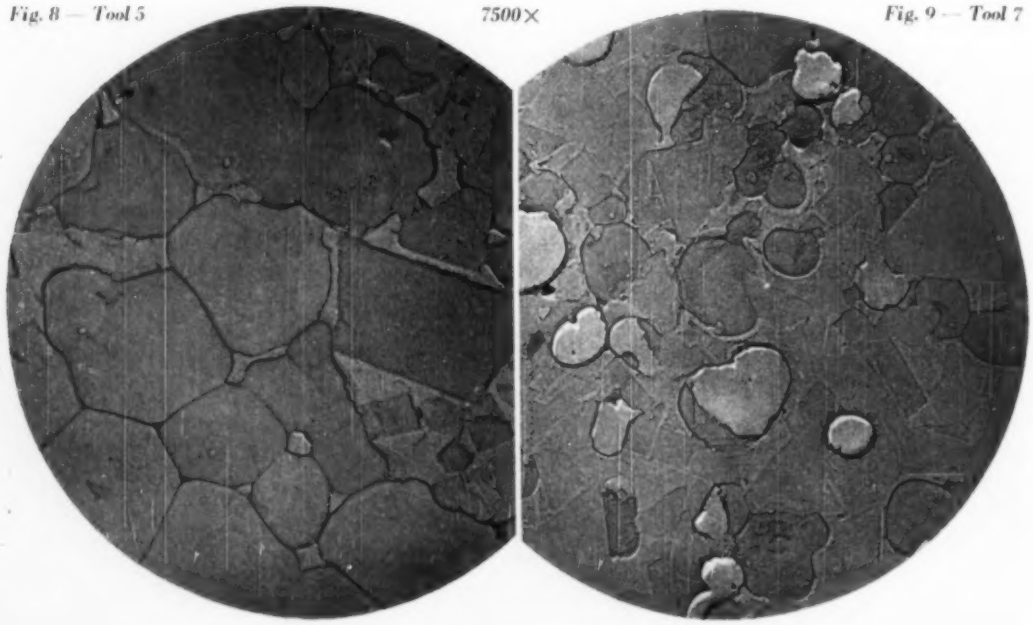
Fig. 7 — Light and Electron Micrographs of Alloy Carbide Compositions, Etched With Alkali-Ferricyanide

example, consider two grades of tools that were recommended for a particular steel cutting job and which exhibit widely different performance characteristics. Light micrographs and electron micrographs of the two grades appear in Fig. 7.

Tool 5 showed good wear resistance and the expected resistance to "cratering". Tool 7, on the other hand, wore away four times faster than tool 5. Tool 7 wore so rapidly that cratering was not a factor in tool life. The reason for the differences in performance of the two tools is not immediately evident from light micrographs. The difference in grain size and soundness is not enough to account for the wide difference in performance.

Consider the electron micrographs of the two specimens, at center of Fig. 7. The first obvious difference concerns the distribution of the alloy carbide grains, identified by their smooth, rounded

Fig. 8 — Tool 5 7500× *Fig. 9 — Tool 7*



contours, as compared with the sharp, angular profiles of the tungsten carbide. The boundaries between the individual grains of alloy carbide are sharply defined, in contrast with the absence of sharp boundaries in some aggregates of tungsten carbide. In tool 5 the alloy carbides form a reasonably continuous matrix with the tungsten carbide embedded in the cobalt that fills the interstitial spaces, while in tool 7 the alloy carbide occurs as isolated islands in a matrix of tungsten carbide and cobalt. It is concluded that the alloy carbide is more effective when it forms a continuous network.

As shown in previous micrographs of straight tungsten carbide compositions and as illustrated by the electron micrograph of tool 5 in Fig. 8, the cobalt binder nearly envelops each tungsten carbide grain, completely filling even the most minute crevice. The cobalt seems to "wet" tungsten carbide well. On the other hand, the cobalt phase seldom completely surrounds alloy carbide grains; this type of carbide tends to form chains. When cobalt is found within a network of alloy carbide grains it is generally coalesced into small globular masses, as also shown in Fig. 8. The cobalt may not fill all the available spaces, which could account for the ineffectiveness of alloy carbides when they do not form a continuous network.

By electron metallography, it is also possible to differentiate and resolve constituents that cannot be identified immediately. Referring again to an electron micrograph of tool 7, Fig. 9, a nodular nonetching constituent is found dispersed throughout the composition. The constituent might be binder metal that did not take part in the metallurgical processes or it might be a complex carbide. In either event, the exact nature of this constituent cannot be determined from electron micrographs of this one specimen alone.

The only means of identifying unknown constituents such as this, microscopically, is the examination of "tailored" specimens by electron metallography. This is precisely the way the problem is being attacked. In cooperation with a manufacturer of cemented carbide compositions, the Process Development Section and the Research Laboratories Division of the General Motors Corp. have set up a program whereby electron metallographic examinations are being made of a series of specimens with constituents and processing conditions varying in a prescribed manner. Electron metallography promises to become a valuable tool in the study of the metallurgical properties of cemented carbide compositions, not only in evaluating performance of tools but also in controlling the quality of product.

Control of Atmospheric Beryllium

By Norman P. Pinto
Metallurgist
Sylvania Electric Products Inc.
Bayside, N. Y.

LARGE-SCALE production of beryllium began in about 1942, spurred by its applications in nuclear energy. Since then beryllium poisoning has been recognized in its true importance. (See, for instance, *Metal Progress* for January, p. 98, and the 1948 Metals Handbook, p. 755.) The quantities of beryllium that may prove injurious are extremely small. The lightness and fineness of the metal powders, combined with the great effect of small amounts inhaled into the human system, are conducive to hazardous exposures and make the handling of beryllium necessarily meticulous.

In Sylvania metallurgical laboratory's facilities for processing beryllium, we have undertaken to incorporate as completely as possible all the precautions and safeguards that extensive medical research has indicated to be necessary.* We have not been able to design for ideal conditions because it was necessary to utilize and convert an existing

*The equipment and facilities described in this article were designed and installed under Atomic Energy Commission contract No. AT-30-1-GEN-224. This report is published by permission of the A.E.C.

building that was not particularly suited for this purpose. Experience in operation under actual working conditions indicates that the precautions are feasible and that the installation is adequate for the maintenance of low atmospheric concentrations of beryllium.

It may not be emphasized too strongly that safe operation of any installation is accomplished only by well-educated and alert workers trained in the understanding and intelligent use of proper techniques in conjunction with well-designed equipment and facilities. The factor that determines the relative safeness of an operation is not the equipment, no matter how well-designed, but rather the operator, or the mind of the operator. It is the attitude and training of the individual worker which determines whether a plant shall be safe.

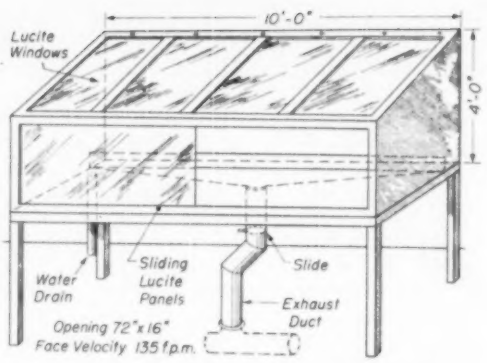


Fig. 1 — Workbench Hood for Handling Beryllium

Tolerance

The safe tolerance dose, commonly referred to as the maximum allowable concentration, has not yet been established for beryllium and its compounds. The establishment of such a limit should be based on medical experience over a considerable period of time, together with significant air-testing data. Comprehensive information of this type is lacking but the available data indicate that concentrations of beryllium in air greater than 25 micrograms per cubic meter are almost invariably dangerous. This is not an established figure but merely a consensus of current opinion. At this laboratory we have established a maximum figure of 1.0 microgram per cubic meter (1 γ per cu.m.), feeling that this is a safe allowable concentration. This quantity is low in comparison with standards for other toxic metals — for example, the accepted safe level of 100 γ per cu.m. for mercury.

Operations

Beryllium is received as powder or solid metal and is stored in sealed containers. The metal may then be crushed and milled to finer powder or may be used directly. The characteristics of the powders are determined by elutriation, screening, chemical analysis, flow measurement, microscopic analysis, and other special techniques. Powders are separated by gas elutriation or screening, weighed, loaded into a die, leveled, and pressed to a compact dense enough to be handled. The characteristics of the compact (for example, density, electrical resistivity and microstructure) are determined, and the compact is sintered at a high temperature in a controlled atmosphere. The properties of this bar are measured, and it may be worked by machining, rolling, swaging, hammering, re-pressing, or drawing to final shape. The metal may be heat treated between shaping operations.

It is a general policy that beryllium or its compounds shall be covered by ventilated hoods during all operations. The only parts of the body exposed to the metal or beryllium-bearing atmosphere are the hands. The hands are gloved as much as is practical.

Ventilation System

The system is designed to distribute heated air uniformly to the rooms and to withdraw the air through the hoods at which the work is done. Both systems are in operation continuously, 24 hr. a day, except for infrequent shutdowns for repairs.

There is a complete change of air in the rooms of the building every 2 min. Because of leakage through doors and windows, the air supply is about 25% greater than the quantity (about 4250 c.f.m.) exhausted through the hoods. The transport velocity within exhaust ducts is maintained between 3000 and 4000 f.p.m., depending on the type of hood and material being exhausted.

Hoods

All the hoods are of sheet metal and lucite construction and are painted with acid-resisting paint. Hoods for operations which use or produce quantities of powder or dust are equipped with drains so that they may be washed completely. When the operation projects particles, baffles or guards are provided to prevent their leaving the hood. The baffles are washed to remove the deposits.

Workbench — The workbench shown in Fig. 1 is used in the general handling of beryllium metal

and compounds, both massive and powdered. All operations such as die loading, transferring, weighing, measuring, cutting, filing, and ball milling are done within this hood. The unit is equipped with a blast gate which may be shut when no operations are being conducted therein and when very high air velocities are required in the rest of the exhaust system. Normally, the gate is locked open.

Use of the hood has reduced the operator's exposure during weighing from 215 to less than 0.3 γ per cu.m. Other operations have produced exposure concentration as follows: sieving of powder, 0.11 γ per cu.m.; cleaning of hood, 0.15 γ per cu.m.; transferring powder, 0.25 γ per cu.m.

Argon-Vacuum Dry Box — This unit, illustrated in Fig. 2, is used in the handling of pyrophoric and toxic powders under an inert atmosphere of purified argon, during operations such as weighing, measuring, transferring, cutting, grinding, and ball milling.

The unit is of steel construction with glass windows ¾ in. thick. The working area is 48 in. long, 24 in. deep and 30 in. high. Two pairs of rubber gloves sealed into openings are provided in the front and side in order that all parts of the hood may be reached and so that two operators may use the working area simultaneously. An outer chamber or gas lock is used to maintain the inert atmosphere when objects are being admitted to or withdrawn from the hood. This lock has an outer door (shown in Fig. 2) and an inner door opening toward and operated from the work area. Illumination is internal. In addition to the usual working tools, a ball mill is located in the hood.

The unit is evacuated by a mechanical vacuum pump connected to the large chamber or the gas lock, or both. About 2 min. is sufficient to reduce the pressure to a vacuum of 30 in. Hg; by proper use of the gas lock, it is not necessary to change this inert atmosphere except when objects larger than the gas lock are inserted. In routine operation, material is placed within the gas lock, the air is evacuated and argon admitted. The inner door is then opened and the material taken into the work area. During use, the dry box is flushed continuously with argon and, to prevent the sweeping of beryllium into the atmosphere, the exit gas is filtered by a Chemical Warfare type of filter.

Pressing of powder compacts without ventilation was found to expose the operator to air containing relatively high concentrations of beryllium. The loading of the compacting die has given concentrations up to 525 γ per cu.m. while the exposure during the entire pressing operation was 130 γ per cu.m. Use of ventilation together with modifications of procedure in filling the die brought about an over-all concentration of less than 0.4 γ per cu.m. during the entire pressing operation.

All operations within 20 ft. of the press are curtailed when beryllium is being compacted. These precautions are established because of the hazard that would arise if powders were spilled. The dies are loaded in hoods where protection is maximum. The working area of the hydraulic press is completely enclosed and is exhausted from the back of the press.

Jaw Crusher Hood — The laboratory jaw crusher is located within a steel hood provided with window, gloves, and a gas lock, similar in design and operation to the argon-vacuum dry box that is shown in Fig. 2. Beryllium is crushed in an inert atmosphere, and the exit gases are filtered.

Sintering Furnace Hood — During the heating of beryllium in a vacuum, metal is evaporated and presents a hazard to anyone near the furnace opening when the furnace is being discharged.

(Continued on p. 382)

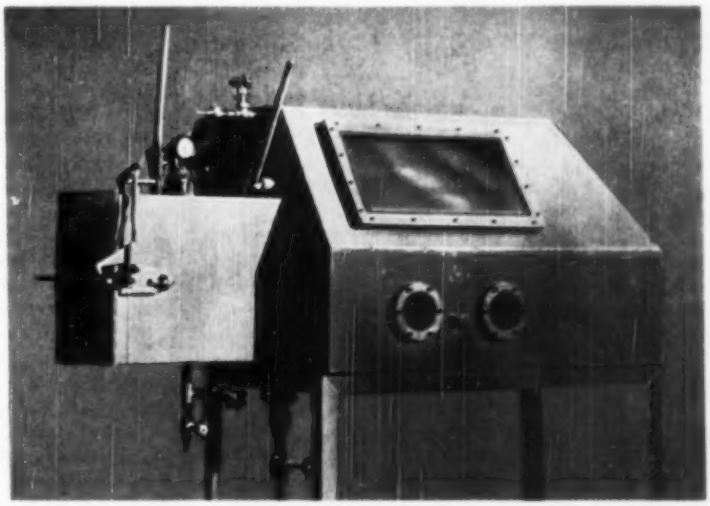


Fig. 2 — Argon-Vacuum Dry Box Used With Pyrophoric and Toxic Powders

Atomic Diameters of Metallic Elements

By Pol Duwez
Associate Professor of Mechanical Engineering
California Institute of Technology, Pasadena

DURING the past twenty years atomic structure has been a subject of ever-growing importance in physical metallurgy. Perhaps that which has contributed most in focusing the attention of the metallurgist on the atom is the outstanding work of William Hume-Rothery, particularly his clear formulation of the rules governing formation of solid solutions and intermediate phases in alloy systems. In applying the Hume-Rothery rules to any particular system, reference must be made to three factors: *(a)* diameter of the atom, *(b)* electron configuration of the atom and *(c)* crystal structure of the element. It seems convenient to bring these together in a single place; the chart on p. 348-B was designed for this purpose.

In this chart, the elements are arranged along a scale of atomic diameter. They are located on several horizontal lines, each corresponding to a given type of electron configuration in the atom. On the first line are the elements having one *s* electron and no *d* electrons (column I-A of the periodic table). On the second line are the elements having one *s* electron and a saturated *d* shell (column I-B of the periodic table). On the third and fourth horizontal lines are the elements having two *s* electrons without and with the outermost *d* shell saturated (columns II-A and II-B of the periodic table). The next four horizontal lines above the atomic diameter scale contain the elements having two *s* and one, two, three, and four *p* electrons, respectively (columns III-B, IV-B, V-B, and VI-B of the periodic table). Below the scale of atomic diameters the transition elements have been arranged on three separate horizontal lines corresponding to the three series of transition elements in the periodic table. It is readily seen that the vertical arrangement of the elements adopted here corresponds to what Hume-Rothery has called the alloying valence. This valence is the number of *s* and *p* electrons for the elements above the scale, and is zero for the transition elements below the scale.

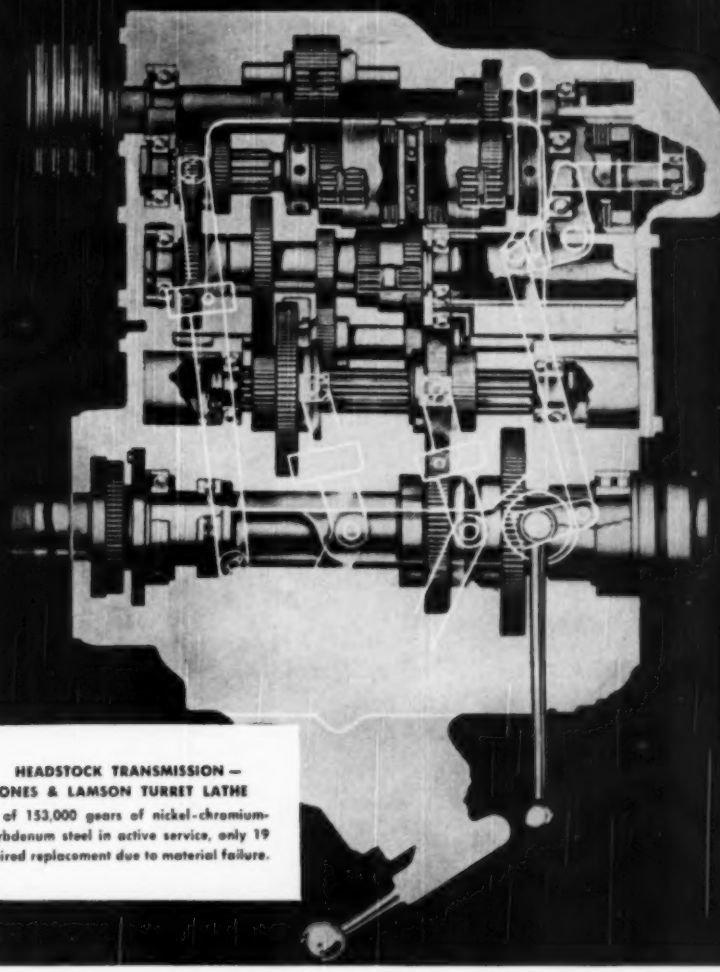
The crystal structures of the elements are indicated on the chart by symbols, which are the same as those used in a previous *Metal Progress* Data Sheet, "Crystallography of the Chemical Elements". For elements having several allotropic modifications, the symbols are accompanied by the usual Greek letters. In order to distinguish the allotropic modifications that are due to a reversible temperature-dependent transformation (as in iron) from those that occur when the metal is prepared under special conditions (for example, tungsten), the Greek letters are placed on the left side of the symbol in the former case and on the right side in the latter.

Most of the values of atomic diameters used in the chart are taken from Hume-Rothery's book, "The Structure of Metals and Alloys". Because of the more or less empirical character of the atomic diameter, the values reported in various tables may not always agree. For a discussion of the exact measuring of atomic size, the reader may refer to the book by Hume-Rothery and also to a more recent discussion by Linus Pauling (*Journal*, American Chemical Society, Vol. 69, 1947, p. 542). All atomic diameters presented in the chart are for coordination number 12. The atomic diameter of silicon, not given by Hume-Rothery, was computed from the lattice parameters of the solid solution of silicon in copper.

The atomic diameter of manganese has been a matter of controversy. The value adopted here (2.60Å) has been proposed by David Harker in a discussion of a paper by A. R. Troiano and F. T. McGuire (*Transactions*, Vol. 31, 1943, p. 340), and is based on the solid solution of manganese in gamma iron. The elements boron, carbon, nitrogen and oxygen have relatively small atomic diameters and fall outside the chart limits. No definite diameter can be assigned to these elements except for carbon, for which 1.54Å is accepted.

The scale of atomic diameter used in the chart is logarithmic. The purpose of the log scale is to determine easily which elements have a diameter within a given percentage of any selected element. This is simply done by copying on a piece of paper the small percentage scale at the bottom of the chart and placing it with its zero on the diameter of the element being considered. The application of the Hume-Rothery rule concerned with size factor is thereby greatly simplified.

CAN YOUR EQUIPMENT MATCH THIS AMAZING RECORD?



HEADSTOCK TRANSMISSION — JONES & LAMSON TURRET LATHE

Out of 153,000 gears of nickel-chromium-molybdenum steel in active service, only 19 required replacement due to material failure.

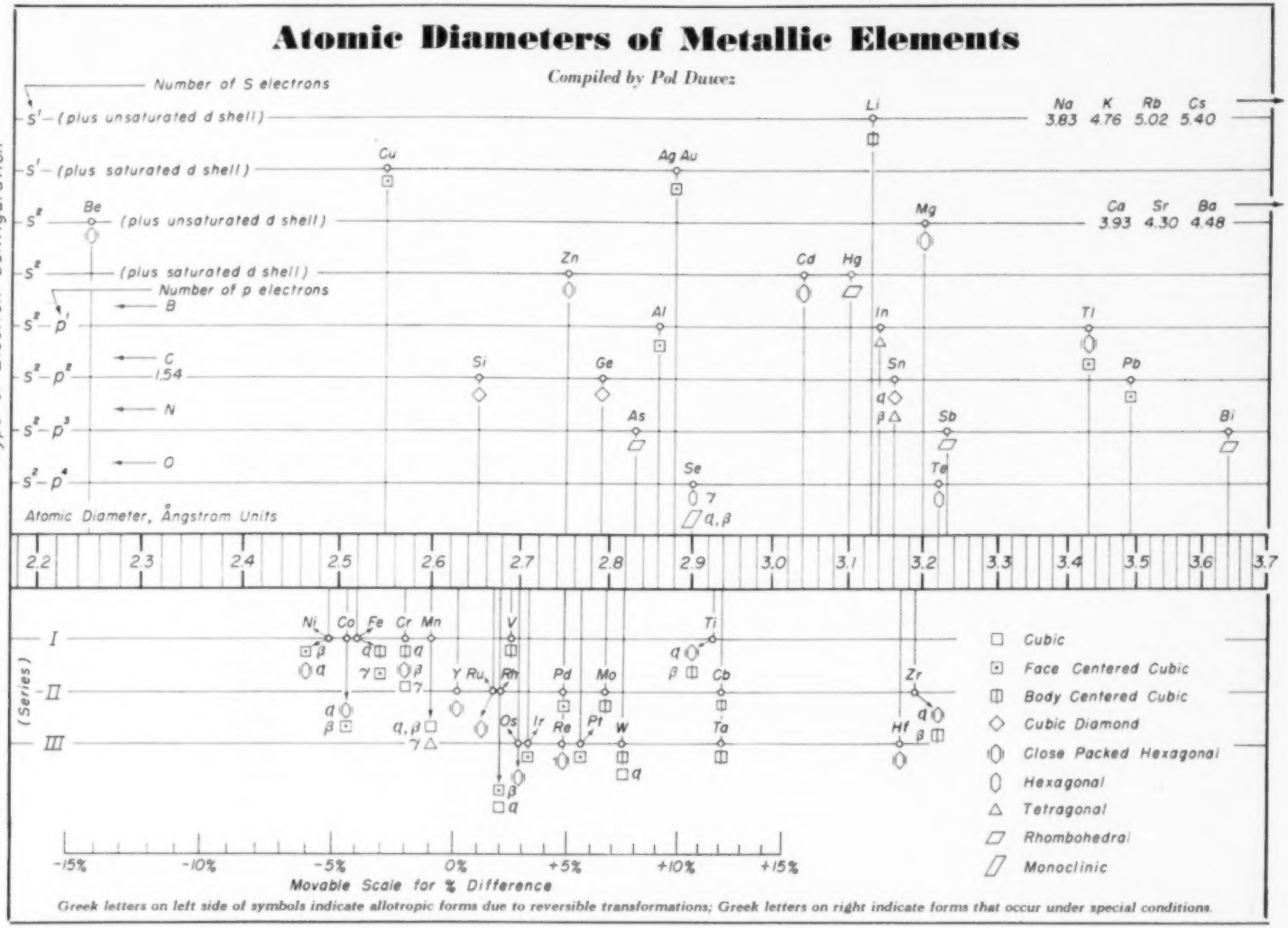
A study of replacements during a 12-month period of World War II revealed an astonishing performance record for nickel-chromium-molybdenum steel gears used in the headstocks of Jones & Lamson Ram Type Turret Lathes. In spite of frequent overloads and punishment due to inexperienced operators, failures were cut to less than 00.02%. Because of this remarkable record, Jones & Lamson Machine Co., Springfield, Vt., continues to specify these shafts and gears in "872" and "874" nickel-chromium-molybdenum steels produced by Carpenter Steel Company, Reading, Pa.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Metal Progress Data Sheet; March, 1950; Page 348-B

Atomic Diameters of Metallic Elements

Compiled by Pol Duwez



Greek letters on left side of symbols indicate allotropic forms due to reversible transformations; Greek letters on right indicate forms that occur under special conditions.

HEATBATH CORPORATION

Water Soluble

LIQUID BATH CARBURIZERS

NEW—*Tried and Proved*

PEN-KARB S-2 and
PEN-KARB S-5

The two-component "easy washing" liquid bath carburizer

PEN-KARB S-3

The single-component "easy washing" liquid bath carburizer

FEATURES:

➡ 1—Operating Range: As flexible as any water soluble liquid bath carburizer 1300°F. to 1700°F.

➡ 2—Metallurgical results equal to the best and better than most easy washing liquid bath carburizers with fast and uniform penetration.

➡ 3—Easy cleansing of small parts of intricate design with blind holes or threaded sections even after oil quenches.

➡ 4—Minimum of fuming and foaming even at elevated temperatures.

➡ 5—Operates with greater simplicity and economy than other easy washing liquid bath carburizers due to careful and proper formulation.

HEATBATH SERVES WITH:

Other liquid bath carburizers
Neutral type hardening salts
High speed hardening salts
Tempering salts
Quenching salts
Black oxide finishing salts such as Pentrate and Kwik-Blak for iron and steel
PX for stainless steel, stainless irons, cast and malleable irons
Dura-Black for copper and brass
Zinc-Black for zinc
Cleaners

CLIP THIS COUPON. MAIL TODAY

Heatbath Corp.
Springfield 1, Mass.

Please send me Data Sheets on:

- ☐ Liquid bath carburizers
- ☐ Neutral Type
- ☐ Tempering
- ☐ H.S. Hardening
- ☐ Quenching
- ☐ Black oxide finishes

Name .....

Company ..... Position .....

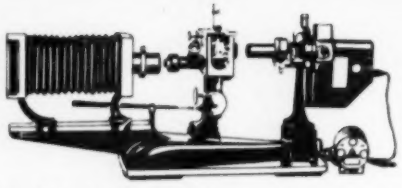
Address .....

HEATBATH CORPORATION

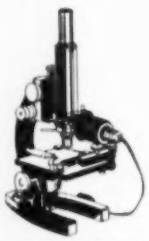
SPRINGFIELD 1 • MASS.

In Canada: Wm. J. Michaud Co., Ltd., Montreal

Designed Especially for SPEED and ACCURACY in ROUTINE ANALYSIS



Bausch & Lomb MILS Metallograph
Here is another metallograph for bright field work, with permanent alignment; Balcoted objectives; stability of image; simplicity of operation. Plate is size 5″ x 7″



B&L CM Metallurgical Microscope. Large stage, space for convenient manipulation. Used extensively for examination of opaque objects, polished metal specimens and similar materials.

B & L Photomicrographic Equipment Model L. For new adaptability, speed, ease, and efficiency in visual microscopy, high and low power photomicrography, as well as photocopying.

The BAUSCH & LOMB ILS Metallograph . . .

provides the complete equipment you need for making daily routine metallurgical examinations (visually or photographically) with bright field illumination . . . quickly, accurately, and easily.

Balcoted objectives, and coated, clear glass reflector help provide superior image quality and increased illumination. Illuminator, inverted microscope, and camera are mounted . . . permanently aligned . . . on a heavy metal base equipped with built-in shock absorbers. This sturdy construction maintains stability of image during long observation and exposure. Plate size is 8″ x 10″. The instrument is in the medium price range.

Design and construction of the Bausch & Lomb ILS Metallograph . . . in common with all B&L metallographic equipment . . . have been dictated by practical daily metallurgical requirements. They are the product of years of research and development in *close collaboration* with leading American metallurgists. That's why you get *better* results . . . *faster* . . . with Bausch & Lomb metallographic equipment.

Write for complete information to: Bausch & Lomb Optical Company, 638-0 St. Paul St., Rochester 2, N.Y.

Bausch & Lomb *Metallographic* Equipment

Test Bar Results Compared With Tests on Components

By A. L. Boegehold
Head, Metallurgy Department
Research Laboratories Division
General Motors Corp., Detroit

WHEN the service performance of a machine part must be improved or when a substitute material is needed, mechanical tests on small specimens do not supply the information required for engineering decisions. For this reason it has become a common procedure to test alternate materials in the form of fabricated components. The first part of this article (in *Metal Progress* for February) discussed the effects of quenching and tempering on the residual stresses in cylindrical specimens. In the present paper evidence will be presented that residual stress is a major cause of the difference between test bar results and tests on components made from heat treated steel.

The magnitude and direction of residual stresses in quenched steel depend on the size of the piece and the depth to which it hardens. This fact has been recognized for at least 20 years, but the quantitative correlation between hardenability and residual stress has never been determined. One reason for the lack of such data is probably the failure of engineers to appreciate that a rather slight increase in hardenability may change the surface stresses of a hardened part from compression to tension. The specific example of this relation shown in Fig. 1 should not be interpreted as an argument in favor of 8640 over 4640. As was indicated in the first part of this article, it is to be expected that the variation of residual stress as hardenability varies within the H band for any one alloy steel will be approximately the same as the differences among various alloy steels of similar hardenability. This variation of residual stress is probably the largest and most serious consequence of hardenability variation within the H band.

How does this apply to automobile components and other heat treated parts?

Suppose we were using 4640 steel for steering knuckles and wanted to consider 8640 as a possible replacement. As shown in Fig. 1, these steels have virtually the same hardenability range. However, variation of hardenability within the range will result in varying residual stress patterns. Thus, before making any decision, it would be advisable to test sample knuckles made from *several* heats of 8640, representing the whole range of

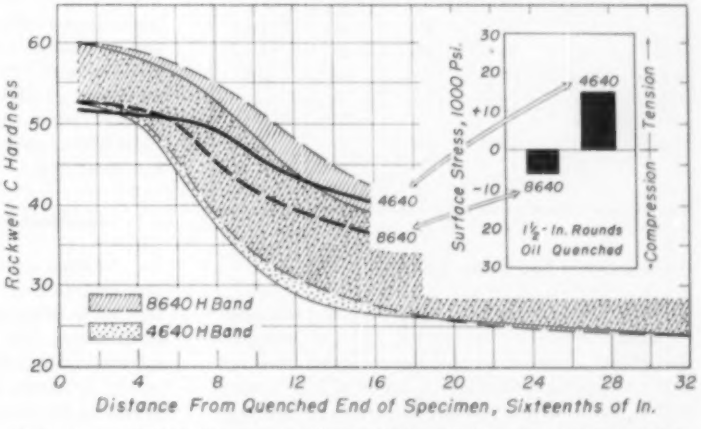


Fig. 1 — A Slight Increase in Hardenability Within the H Band May Change Residual Surface Stresses From Compression to Undesirable Tension

hardenability that would be encountered in production. Any heat within the hardenability band for either steel would harden throughout the section of a small standard test bar and, so far as conventional tensile and fatigue properties are concerned, the two steels would be equivalent. However, the residual stresses developed in the actual parts might easily be quite different in the two steels if the results from only one heat of each steel were considered. The results of such limited tests would indicate one of the steels to be better than the other, whereas if the whole range of hardenability were considered, the steels would be equal.

A survey of the automotive industry several years ago showed that practice was far from uniform as to allowable as-quenched center hardness of steering knuckles. Table I shows the practice employed at seven plants. Based on performance in service, all these different practices result in adequate knuckles, but it would be interesting and highly enlightening to take knuckles representing all variations of the current practice and split them longitudinally so that an indication could be obtained concerning the residual stress. The evidence from such testing might indicate that a greater factor of safety could be obtained by treating to obtain favorable residual stresses.

Table I — Comparison of Steering Knuckles
(Data From Seven Manufacturers)

Co.	Steel	Min. Hardness As Quenched		Corresponding % Martensite	
		Surface	Center	Surface	Center
A	8645	45	—	70	0
B	4140	54	48	95	85
	4140	42	36	50	10
C	5135	45	40	90	50
D	8630	50	40	100	70
E	8647 4052	56.5	56	95	95
F	1340	44.5	29	70	0
	9440	43	36	55	10
G	1335	55	36	100	30

Fatigue and Static Strength of Axles

The stresses in axles might seem susceptible to simple analysis. Torsional loading produces maximum stresses in the outer layer, and the engineer has sometimes been tempted to conclude that a few simple tests on bars treated to correspond with the surface metal would suffice to insure satisfactory performance in service. Such

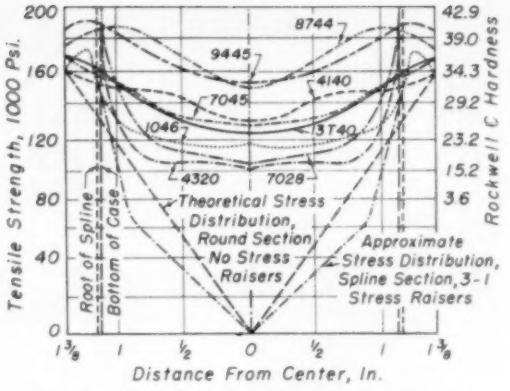


Fig. 2 — Cross-Sectional Hardness and Strength of Axles After Heat Treating. Steels 7028 and 7045 contain 1% manganese and 0.28 and 0.41% molybdenum respectively. (H. B. Knowlton)

a notion is disproved by the fatigue tests on rear axles that were reported by H. B. Knowlton in *Metal Progress* for December 1943. Figure 2 shows the cross-sectional hardness of eight different steels in 2¾-in. diameter axle-shafts. All had surface hardness the same within normal manufacturing limits. The fatigue test results shown in Fig. 3 bear no relation to the surface hardness or the cross-sectional hardness. The fatigue limits vary all the way from 17,500 to 28,000 psi., a spread of 40% in material that varies only about 15% in tensile strength or hardness as determined on test bars. Nor do the uncarburized steels with the highest tensile strength have the best fatigue resistance in the 2¾-in. diameter axle shaft. In presenting these data six years ago, Mr. Knowlton mentioned residual stress as a probable factor in the fatigue behavior. His statement that "residual stresses need further study" is just as apt in 1950 as it was in 1943. In my opinion, residual stress is the factor primarily responsible for lack of correlation among the fatigue and static test data for these axles.

Residual Stresses in Large Ring Gears

Another example that illustrates the failure of test bar data to indicate service performance is that of a large herringbone ring gear about 5 ft. in diameter, part of a marine power-transmitting system. Calculations showed that strength equivalent to a hardness of Rockwell C-20 to 25 would provide adequate life. 1340 steel was used. Figure 4 shows the condition of the gear after running for a comparatively short time. Note the multi-

plicity of cracks at the root of the teeth. The cross section of the gear blank ring at the time it was heat treated was about 2½ x 5 in. Obviously, 1340 would not harden through such a section. The shallow layer that did harden was removed from the inside of the ring in the process of cutting the internal gear teeth. This removed the material in

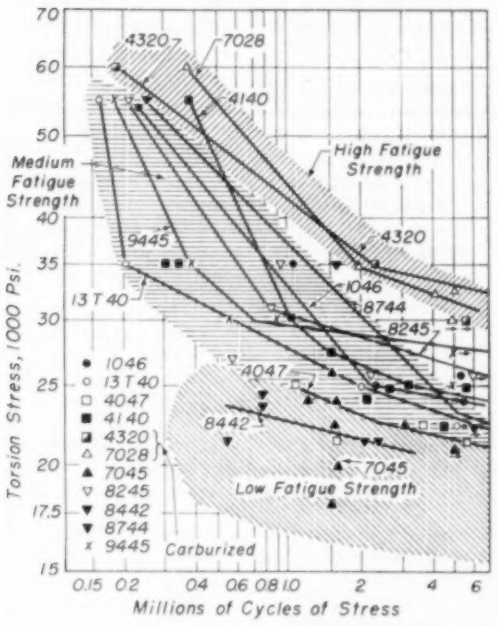


Fig. 3 — Torsional Fatigue of 2¾-In.-Dia. Splined Axles Made From Steels of Fig. 2. (H. B. Knoulton)

which compressive stresses existed and exposed the interior metal, which was in tension. The compressive stresses in the original hardened surface were demonstrated by measuring the curvature of sections cut from the ring. The radius of curvature was decreased from 28.706 to 28.538 in. by cutting segments from the complete ring. A gear of the size in question would have been much better if made from 4340 so that hardening (and its associated strengthening) would occur throughout the whole cross section.

A fatigue or tensile test on 1340 hardened and tempered to Rockwell C-20 to 25 gives no idea of the load-carrying ability of the gear teeth. Even if the test specimen were cut from the heat treated ring gear blank, we would have no better information because the mere cutting of the specimen from the blank would relieve the residual stresses. Besides knowing the mechanical properties of metal, we must also know the effects of section size and heat treatment on the residual stresses. Usually the best way to determine the net result is by testing the fabricated part itself in a fixture that simulates actual service.

Carburized Parts

When steel is provided with a high-carbon case of varying depth, stress analysis becomes exceedingly difficult. At one time we had faith in the simple rule that any case hardened steel member ended up with the surface in compression and the core in tension. Later on this rule was modified to accommodate the evidence consisting of carburized gears in which cracks appeared at the surface — obviously, the result of tensile stresses. The "explanation" advanced to fit this event was that when the core hardness exceeded Rockwell C-40 with a high ratio of core to case thickness, the volume increase accompanying martensite

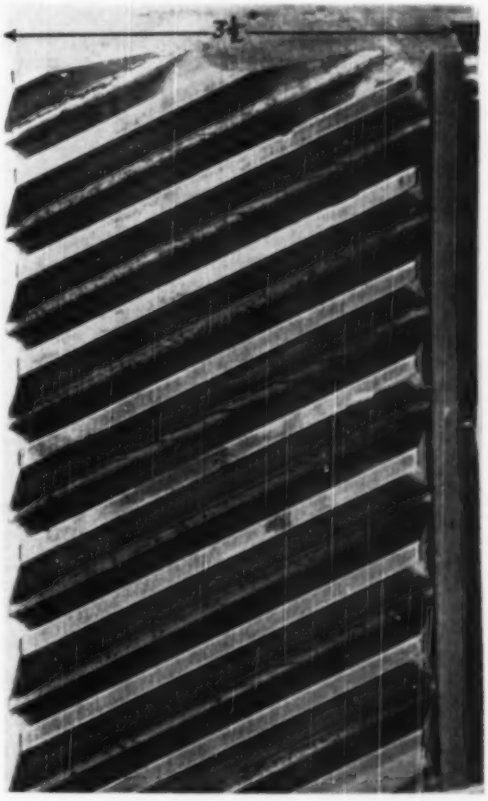


Fig. 4 — Ring Gear After Short Service

formation in the core would produce tensile stress in the case. It was presumed that in pieces having a core hardness less than Rockwell C-40 the case would always be in compression. The rule has again had to be modified to fit the facts observed when we tested certain king pins to determine the condition of stress in the case.

We had steering knuckle pins made of 8620 steel, carburized and hardened to a depth of 0.030 in. and with a core hardness of Rockwell C-28. When these were cut longitudinally but not completely severed at one end, simulating the two branches of a tuning fork, the free ends moved apart, making the outer surface concave and indicating tension in the case. It was reasoned that here was an example where the core controlled the situation because of the lightness of the case. Presumably, in expanding below M_s, the case was resisted sufficiently by the core to cause the case to exceed its yield point, thus shortening it.

Another king pin, given a 0.050-in. case and with the core heat treated to the same hardness (Rockwell C-28), was split and showed compression in the case by the ends of the fork moving together. The thicker case was strong enough to prevent shortening; therefore, it remained in compression.

The effects of other heat treatments are shown in Table II. The original treatment (A) left the surface in tension, as indicated by tests on six knuckle pins split longitudinally. Another group (B), quenched in oil instead of water, had compressive stresses at the surface. Since the final result was the net effect of several processing steps, it was desired to determine the influence of each part of the treatment. Group C shows that after the king pins were hardened by quenching in oil, the surface was in tension (contrary to accepted ideas).

Group D shows that tempering at 300° F. made the tension greater! (Tempering at 300° F. has always been considered useful for relieving stresses that originate in hardening.) In the light of known facts about contraction caused by the tempering of martensite, the increased tension is exactly what should have been expected. We have to conclude that annealing the middle portion of the pins and grit blasting were responsible for the pins in group B being in compression, at least in the center section. Group E was treated the same as group C except that the case was made 0.049 in. deep, instead of 0.030 in. This resulted in compression, instead of tension, in the case. Tempering decreased the compressive stress (group F). After adding center anneal, grit blasting, and grinding, the knuckle pin was in a favorable condition of stress.

This series of tests indicates that the state of stress should not be assumed from any casual observation or snap judgment. The various combinations of factors that can influence the condition of stress are so many and so varied that it would seem wise to make tests in each important instance to be sure what the stress situation really is. This can be done by methods that are already well known and widely used; these methods involve removing metal by turning, boring or splitting the part and measuring the changes in dimensions.

The several factors that can vary to produce

Table II — Surface Stress in King Pins

Group	Treatment	Change in Diameter*	Surface Stress
A	Carburize at 1650° F.	+0.013	Tension
	Case 0.030-0.040 in.	+0.014	
	Cool to 1600° F.	+0.012	
	Direct quench in water	+0.009	
	Temper 300° F., 1½ hr.	+0.019	
	Anneal central 1¾ in.†	+0.015	
	Grit blast; ground		
B	Same as A	−0.006	Compression
	except oil quench	−0.003	
		−0.006	
		−0.005	
		−0.003	
C	Carburize at 1650° F.	+0.009	Tension
	Case 0.030-0.040 in.	+0.006	
	Cool to 1600° F.	+0.017	
	Direct quench in oil		
D	Same as C, plus	+0.019	Tension
	temper 300° F., 1½ hr.	+0.019	
		+0.024	
E	Same as C, except	−0.009	Compression
	case depth 0.049 in.	−0.013	
		−0.026	
F	Same as E, plus	−0.007	Compression
	temper 300° F., 1½ hr.	−0.006	
G	Same as F, plus	−0.012	Compression
	center anneal†	−0.015	
	and grit blast	−0.016	
H	Same as G, plus	−0.014	Compression
	finish grind	−0.016	
		−0.021	

*Change of diametral dimension at cut end perpendicular to cut 3⅛ in. long made longitudinally in king pin 3⅜ in. long and 0.938 in. diameter.

†Leaving ¾ in. hard on each end.

either tensile or compressive stresses at the surface of a carburized and heat treated steel part are:

1. Depth of hardening.
2. Amount of tempering after hardening.
3. Depth of carburized case.
4. Thickness of core.
5. Ratio of case to core thickness.
6. Relative cooling speed of case and core.
7. The M_s temperature.
8. Amount of retained austenite after quench.
9. Magnitude of volume increase on hardening.
10. Yield strength and creep resistance at elevated temperature.

These ten variables provide a sufficiently complicated situation to make me feel perfectly safe in challenging any mathematician to calculate the state of stress that will result from any combination of the variables. It is fortunate that we need not rely on calculations. We can get a fairly accurate answer by experimental methods.

Tubular Sections

Another common source of unfavorable stress is the practice of quenching only the outside of a tubular or hollow section. This is especially bad if the outside of the tube is carburized. The outer layer cools down to the M_s point faster than the inner layer. Therefore, the inner layer is pushed toward the center and plastically shortened; that is, the inside diameter is decreased. When the upset inner layer cools to room temperature, it is then in tension. The best way is to quench the inside and outside surfaces at the same time. If the hardenability of the steel is so great that this drastic quenching would cause full hardening and cracking, then "time quenching" is indicated. In any event, quenching only on the outside should be avoided.

One example of this kind was a heavy-duty transmission gear made of 3312 steel with a hollow shaft integral. By keeping the quench out of the hole in the shaft, the inside surface at the root of the splines was subjected to a tensile stress of 6000 psi., which, of course, decreased the load-carrying ability of the gear by that amount.

Rear Axle Ring Gears

The effect of size difference between test bars and rear axle gears, as affecting the order of fatigue resistance of case hardened steels, is illustrated by some tests reported 15 years ago (A. L. Boegehold and J. O. Almen, *Proceedings*, A.S.T.M., Vol. 35, 1935, p. 99). Fatigue test ratings of steels tested with plain rotating-beam bars (R. R. Moore type), notched bars, and in the ring gears themselves, are given in Table III. The steel and treatment that had the best life in the ring gear test showed up next to last in the notched-bar fatigue test. The steel and treatment that showed best in the notched-bar fatigue test was fourth in the tests of actual rear axle ring gears. The lack of agreement could all be due to the nature of tooth contact resulting from distortion of the gear teeth in hardening. Also, the residual stress in the gear teeth is probably quite different from that in the test bars. At any rate, we cannot depend on fatigue tests of small specimens to tell us how a certain steel will behave in the actual ring gear or pinion.

Table III — Comparison of Steels and Treatments of Case Hardened Rear Axle Gears

Steel	Case Depth	Quench	Reheat	Cycles Till Failure at ±120,000 Psi., Plain Specimens	Cycles at 50,000 Psi., Notched Specimens	Cycles Till Failure in Rear Axle
2315	0.042-0.053	Direct	1330° F., Oil q.	160,000	250,000	812,628
2315	0.047-0.053	Direct	Oil q.	900,000	500,000	286,181
2315	0.053	Transferred	—	—	1,000,000	486,802
		from carburizing box to furnace at 1375° F. before oil quenching				
2315	0.047	Direct	1475° F., Oil q., Cyanide	3,000,000	—	403,782
2330	0.030	Direct	1375° F., Oil q.	20,000,000	1,200,000	323,925
MnMo	0.060	Direct	Oil q.	—	200,000	268,426
1315	0.067	Direct	Oil q.	—	500,000	302,863

Plain and notched specimens were R. R. Moore type. All steels tempered at 300° F.

Residual Stresses From Nitriding

Nitriding is frequently regarded as a process for obtaining a hard surface on steel without incurring the dimensional changes that accompany other methods of hardening. This concept is acceptable when applied to articles having sub-

stantial thickness. For articles having thin sections, however, the process of nitriding causes appreciable dimensional growth and distortion. The nitrided surface layer on Nitralloy 135, when free to take its normal dimensions, will increase in length about 0.020 in. per in., depending on the duration of nitriding. When the piece being nitrided has sections many times the thickness of the nitrided case, the case is not strong enough to alter the dimensions of the piece; the nitrided layer is prevented from expanding, but it does exert a force tending to stretch the core and in so doing produces compressive stresses in the outer layer. Therefore, nitriding has come to be used for generating compressive stresses in the surface layers of parts that are to be subjected to high cyclic stresses.

The designer must understand that the lighter the piece to be nitrided, the greater will be the linear growth in the nitrided article, and the lower will be the compressive stresses in the nitrided layer. With no core to hinder growth of the nitrided layer, the maximum dimensional increase will occur and the nitride layer will contain no compressive stress.

Nitrided Crankshafts

One consequence of this size relation is that we cannot tell from a rotating-beam fatigue test specimen 0.300 in. in diameter how much improvement in fatigue resistance can be expected as a result of nitriding a particular part, for instance a crankshaft that is made up of sections from $\frac{5}{8}$ to 2 in. thick.

A comparison of the fatigue limits determined on a crankshaft of such size and on fatigue specimens 0.300 in. in diameter is shown in Fig. 5. Here it is seen that the test specimen has a fatigue limit of 95,000 psi., while the fatigue limit of the crankshaft, heat treated and nitrided exactly like the small specimen, has a fatigue limit of 120,000 to 130,000 psi. The nearest approach to obtaining similar results on both the crankshafts and the test specimens was realized when the crankshaft and the test specimens were made of 4340 steel, hardened and tempered to between 312 and 340 Brinell but not nitrided. Also, shot peened fatigue test specimens had endurance properties in close agreement with results on the crankshaft itself. However, this result was not predicted from the test bar results. Before the crankshaft tests were made it was reasoned that, due to the presence of end grain in the fillet between crank cheek and journals and pins, where crankshaft failures occur, the crankshaft would be more accurately represented by a test bar in which the flow lines were transverse. Figure 6 shows the flow lines in a crankshaft forging. Although there is no flow line runout in the forging, the removal of metal in machining the journal to size results in end grain at the fillets.

Transverse Flow Lines

To get fatigue specimens with flow lines transverse, the specimens were cut from the region outlined in Fig. 6. Fatigue results from such test bars are shown in Fig. 5. It will be seen from Fig. 5 that values for crankshafts predicted from test bars having transverse flow lines would be quite erroneous. The crankshafts behaved in fatigue testing just as if there were no end grain in the fillets. Presumably, the condition of surface stress in the neighborhood of the end grain was such as to nullify the weakening effect that end grain would ordinarily be expected to have.

Although in the crankshaft tests just discussed, the effect of end grain was not prominent, it would be well to recognize that, in general, the fatigue properties *are* affected greatly by the relation of flow line direction to direction of stresses from applied loads. When flow lines are perpendicular to stresses produced by an applied load, there is a stress-raising effect approaching that of a 60° notch, depending on the nature of the banding or flow lines.

Figure 7 shows fatigue test results on notched and plain bars, some with longitudinal and some with transverse flow lines. Notching equalizes the fatigue resistance of both longitudinal and transverse test bars but flow lines by themselves approach the damaging effect of the 60° notch.

If tests are made on enough heats, a range of transverse fatigue resistance is found such as shown in Fig. 8. The two S-N curves include an area in which most of the black spots fall and represent the high and low fatigue curves for transverse specimens cut from forging bar stock from a large number of heats of 4340 used for making crankshafts. The black spots represent tests on specimens cut from finished crankshafts taken at a position corresponding to the locations outlined in the longitudinal section of a forging in Fig. 6.

At least three observations are justified by these data:

1. The process of forging makes no improvement in the fatigue resistance of transverse specimens.
2. Stress concentration due to flow lines or end grain, varies within rather wide limits.
3. Test results on such specimens are unsuitable as a means of forecasting crankshaft performance.

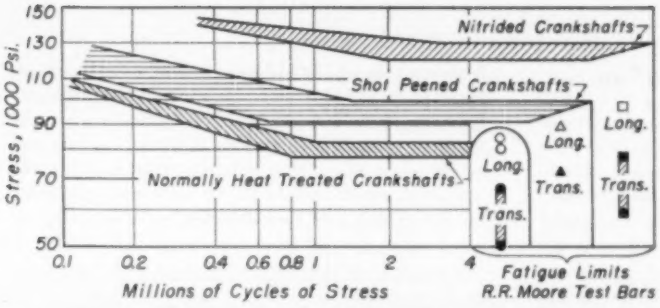


Fig. 5 (Left) — Fatigue Limits of Crankshafts (S-N Bands) and R. R. Moore Test Bars Cut From Crankshaft Location Outlined in Fig. 6. Fatigue limits for the test bars are indicated at right. Steel is 4340

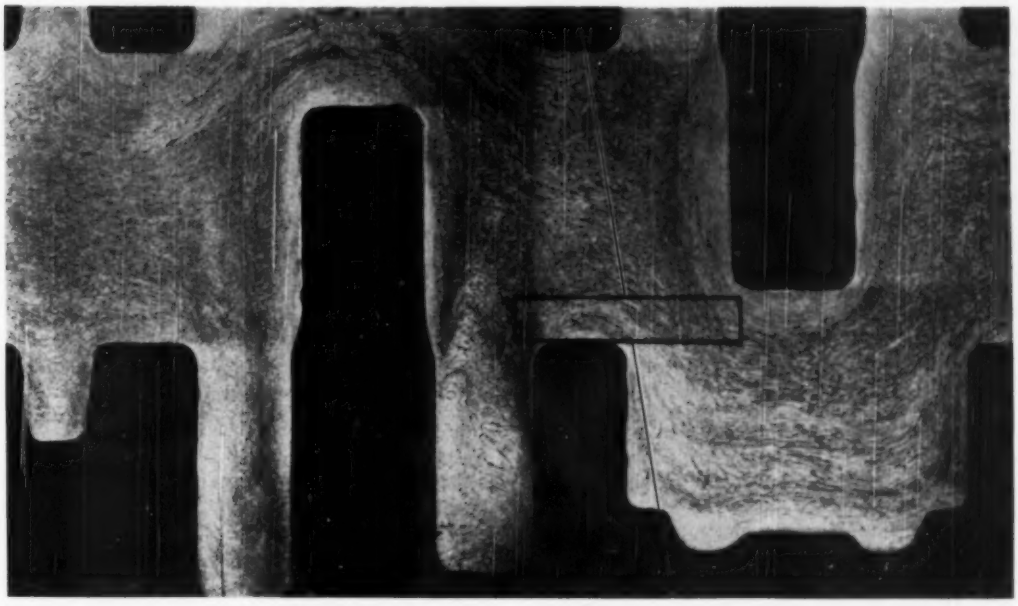
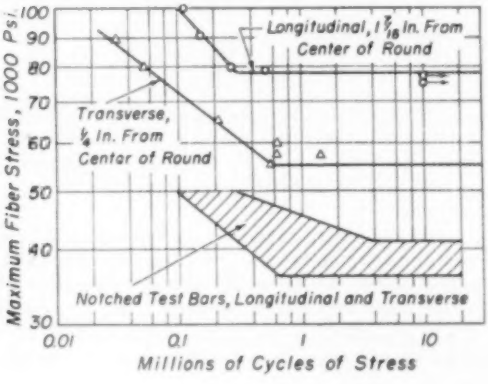


Fig. 6 — Macro-Etched 4340 Crankshaft Showing Location From Which Fatigue Test Specimens Were Cut

Fig. 7 — Effect of Transverse Flow Lines on Fatigue Resistance of Plain Test Bars of 4340 Steel



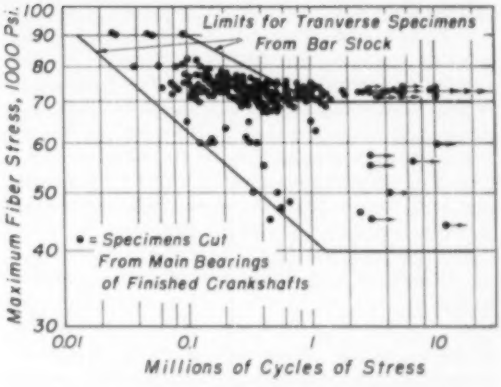


Fig. 8 — Fatigue Resistance of Specimens Cut From Main Bearings of Finished Crankshafts at Location Outlined in Fig. 6. S-N curves represent limits for transverse specimens cut from forging bar stock from many heats of 4340

Core-to-Case Ratios in Nitrided Parts

Again reverting to the question of nitrided members, tests were made on nitrided fatigue specimens cut so that flow lines were perpendicular to the axis of the specimen. The fatigue limit range of 58,000 to 75,000 psi. was lower than on nitrided specimens having flow lines parallel to the specimen axis.

The fatigue resistance of nitrided pieces depends on the strength of the core material because failure begins at the junction of case and core. Where the flow lines are normal to the specimen axis, the yield point may be 104,000 to 130,000 psi. and the tensile strength 147,750 to more than 155,000 psi., as compared with 130,000 psi. minimum yield point and 155,000 psi. minimum tensile strength when flow lines are longitudinal. Therefore, it is to be expected that the benefit of nitriding will be less when flow lines are transverse.

The true fatigue resistance of the nitride surface layer is the same on the crankshaft as on the fatigue test specimens. The superior fatigue resistance of the crankshaft over the test bar is due to smallness of the tensile stress in the core immediately below the nitrided case of the crankshaft. The total compressive load on the case must be balanced by the total tensile load on the core. The larger the area of the core, the lower will be the unit stress in the core needed to hold the nitride layer in compression. The smaller the cross section of the core, the higher the tensile stress in it to balance the force exerted by the case. As a result of this higher tensile stress, the smaller will be the applied stress required to produce fatigue failure.

By knowing how much the nitride case would grow if unrestrained during formation, we can calculate the stresses developed. The two curves in Fig. 9 show the growth in rings of Nitralloy 135 due to nitriding, after data by Hubbard and Robinson reported in a publication of the Nitralloy Corp. The two additional points, expressed in growth per inch, were obtained in our laboratory by through-nitriding samples of 4340 and Nitralloy 135 which were only 0.015 in. thick. From these we determined that the growth of 4340 was 0.006 in. per in., and for Nitralloy 135, 0.0207 in. per in. Using the figure for 4340 we can calculate induced stresses. A core cross section great enough to completely overcome this growth of 0.006 in. per in. would result in a compressive stress of 180,000 psi. in the case (assuming a modulus of elasticity of 30,000,000 psi. for the nitrided layer). Conversely, a core so slight as to allow the full 0.006 in. per in. growth in the case would develop a tensile stress of 180,000 psi. or would rupture if its tensile strength were less than 180,000 psi. Between these two extremes, the tensile stress in the core and the compressive stress in the case would depend on the ratio of their areas. The tensile stress generated in the core will determine the amount it stretches elastically. The complete

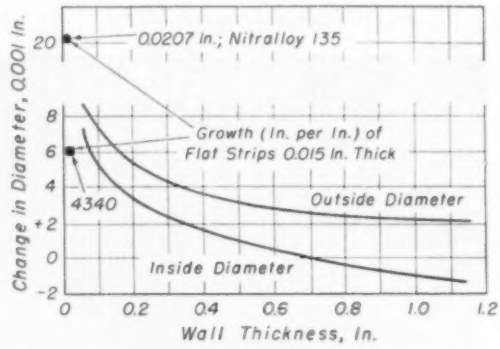


Fig. 9 — Growth in 2¾-In. O.D. Rings or Cylinders of Nitralloy 135 Due to Nitriding for 72 Hr. at 975° F. (Hubbard and Robinson). The two points for flat strip were added by the author

restraint of the case expansion will, therefore, be reduced by that amount and will determine the compressive stress developed in the case. This situation is represented by the formula:

$$N \times K = C \times H$$

where N = area of the case, K = compression of the case, C = area of the core, and H = extension of the core.

Since K, the compression of the case, is equal to the extension of the case when it is unrestrained minus the actual extension of the core,

$$K = (0.006 \text{ in.}) - H, \text{ and}$$
$$C \times H = N\,(0.006 - H),$$

which reduces to:

$$H = \frac{0.006\,N}{C + N}$$

Multiplying the extension of the core (H) by the modulus of elasticity (30,000,000 psi.) gives the unit stress in the core. Multiplying $(0.006 - H)$ by 30,000,000 gives the unit stress in the case.

Plotting these values for various ratios of case and core, we have the curve in Fig. 10. This explains the variation in fatigue resistance of nitrided test bars and crankshafts. The core stress must be added to the stress from externally imposed load in order to determine the true fatigue

limit of the core. The ratio of core to case in the crankshaft is 16.8, and in the R. R. Moore test bar it is 5.0. Using these ratios we can determine from Fig. 10 what tensile stresses exist in the core as a result of the compressive stress in the nitrided case.

Table IV shows values for fatigue limits. R. R. Moore test bars with flow lines parallel to the axis show a fatigue limit of 95,000 psi. The stress corrected to the root of the case would be 85,500 plus 30,000 residual stress applied by the case, giving a net fatigue limit of 115,500 psi., which is near the fatigue limit for the crankshaft. The

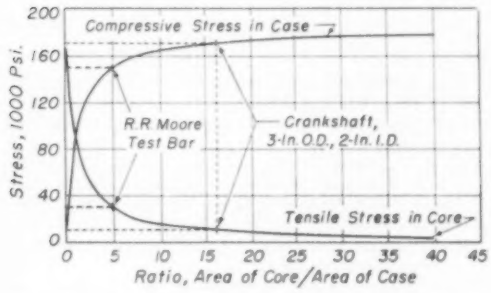


Fig. 10 — Calculated Stresses in Nitrided 4340, Based on Maximum Case Growth of 0.006 In. per In.

lower fatigue limit of the specimens with flow lines normal to the axis can be accounted for by the stress-raising effect of the flow lines.

The question may be raised — why is the fatigue limit for the crankshaft as high as 128,500 to 138,500 psi. in a steel that normally has a fatigue limit of only 80,000 psi.? J. O. Almen has pointed out that when fatigue failure can be prevented at the surface of the specimen, the fatigue limit becomes the same as the yield strength. Since the yield strength of 4340 at the hardness used for these crankshafts is 130,000 to 140,000 psi., Almen's theory appears to be supported in this instance.

The concept of core stress varying with the ratio of core to case area makes it obvious that nitriding will be of negligible advantage for stressed members if the core is too light. As a matter of fact, the improvement in fatigue resistance will be nil or negative when the core is so light that it ruptures. That is exactly what happened during the war when we tried to improve the life of a firing pin by nitriding. The pin was so light that nitriding ruptured the core and the pin broke in less time than normal. It is obvious, therefore, that no one test bar will represent the wide range of conditions that can exist in nitrided steel sections.

The same can be said for any other method of heat treating to obtain high fatigue properties. Every set of conditions produces a certain net result that will be difficult to predict from results obtained under different conditions.

Conclusion

There is need for a large amount of information concerning the relation of hardenability, section size, quenching severity and tempering procedure to the magnitude and direction of residual stress. A thorough knowledge of the sequence of linear expansions and contractions during heat treatment frequently leads to an accurate prediction of the *direction* of residual stresses and, by predicting their direction, we can avoid certain combinations of section size, heat treatment and material that result in unfavorable stresses, for instance, tension at the surface.

But the *magnitudes* of these stresses are also important. These cannot be predicted; experimentation is necessary. Tedious as this experimentation may be, it would seem worth while as a means of evaluating steels before they are tested — at great cost — in the form of fully fabricated components. If many investigators will take up this work, they should supply us within 10 or 15 years with the next chapter in the metallurgy of steel — a chapter that is badly needed!

Table IV — Fatigue Limits of Nitrided 4340 Steel

Object Tested	Fatigue Limit Stress Due to Externally Applied Load	Stress at Root of Case*	Residual Tensile Stress in Core	True Fatigue Limit
Crankshaft	130,000 psi.	128,500 psi.	10,000 psi.	138,500 psi.
	120,000	118,560	10,000	128,500
Test Bar, Flow Lines Axial†	95,000	85,500	30,000	115,500
Test Bar, Flow Lines Transverse†	75,000	67,500	30,000	97,500
	58,000	52,200	30,000	82,500

*Failure begins at the root of case, whose depth was calculated as 0.015 in.
†Test bars with flow lines were R. R. Moore rotating-beam specimens.

Russian Opinions on Evaluation of Metals by Mechanical Tests

Reviewed by E. P. Klier
School of Engineering
University of Maryland
College Park, Md.

FOUR years ago the Russian monthly, *Zavodskaya Laboratoria,* reported the response to a questionnaire on equipment and instruments for mechanical testing. The answers "provided considerable aid in the development of national instrument construction within the field of material testing", and the editors of the Russian periodical were encouraged to try again, with questions on some of the more complex aspects of mechanical testing.

This second questionnaire dealt with both the theoretical and practical aspects of evaluating materials by mechanical tests. Because of the diverse interests of the specialists who are quoted in the second report (*Zavodskaya Laboratoria,* Vol. 14, 1948, p. 446 to 486), considerable conflict of opinion has resulted. The editors of the Russian journal state that it is impossible to agree with some of the replies and have promised to adjust the conflicts in a later issue of the journal.

The questions consist of four groups, dealing with: *(a)* the general character of mechanical properties, *(b)* evaluation of the structural behavior of materials as a result of mechanical tests, *(c)* evaluation of the fabrication characteristics as a result of mechanical tests, and *(d)* quality control. The published report contained the replies of:

S. S. GRJIBOWSKY, chief construction engineer of J. V. Stalin's Novokramatorsky Equipment-Building Plant.

S. S. MANEVITCH, chief of the central laboratory of the Kazan Plant.

A. M. PALIY, head of the mechanical laboratory of the Omsk Plant.

J. M. POTAK, acting head of the Moscow laboratory, "V.I.A.M." (His reply was largely an essay on the philosophy of testing and does not lend itself to categorical review. However, some of his pertinent observations are presented in the answers by other respondents.)

S. B. SERENSEN, active member of the Academy of Science, Ukraine S.S.R.

J. B. FRIEDMAN, professor of technical science, "V.I.A.M."

A. M. TCHEREMUKCHIN, honorary worker in science and technique, professor of technological sciences, and leading designer of the Moskva (aircraft) Plant.

E. M. SCHEVANDIN, scientific collaborator of the Shipbuilding Institute.

S. I. GUBKIN, active member of the Academy of Science, White Russia S.S.R. (No review is offered here concerning the contribution of this respondent, who submitted a lengthy mathematical discourse — 13 pages of the total 41 — on plasticity and brittleness.)

The questions and a digest of the replies are as follows:

(A1) — "Is it advisable to classify mechanical properties as simple or primary and complex or secondary?"

Yes — 6; No — 2.

This is a surprising return, but was undoubtedly fostered in part by the wording of a later question (A3) in which yield strength and tensile strength are offered as examples of "simple" mechanical properties, and impact strength and strength of a notched sample are given as typical of "complex" mechanical properties.

In support of the minority view, S.S.G. argues that it is not feasible to separate mechanical properties because contemporary knowledge makes it impossible to determine which properties are primary and which are secondary, and A.M.T. contends that among aeronautical engineers there is no need for the classification suggested.

The weightiest argument for the classification of mechanical properties introduces the concept of flow strength and fracture strength. This concept, it is contended, leads to a better understanding of the mechanical behavior of metals. However, it is

agreed that as yet there is no clear-cut means of establishing the divisions of primary and secondary mechanical properties.

(A2) — "Is it expedient to consider plasticity as a complex property dependent on the resistance to failure, stiffening and yield strength of the material?"

It was generally agreed that plasticity could *not* be defined satisfactorily in terms of the three characteristics mentioned. S.S.M. introduced the idea that plasticity (as measured by elongation and reduction of area) depends on size of sample, condition of surface and speed of loading to a much greater extent than the tensile or yield strengths. J.B.F. noted the difficulty in considering plasticity as a function of the stiffening (work hardening), since this, in turn, depends on the plasticity. There was a suggestion by S.S.G. that "plasticity does not depend at all on the mentioned properties; it only accompanies them" and is an elementary or simple mechanical property (in the sense of malleability). Perhaps E.M.S. gave the best answer. He said, "The question is still debatable."

(A3) — "In establishing a connection between the structure and the mechanical properties, should only the simple properties, such as yield strength and tensile strength, be considered, or should the more complex properties, such as impact strength and the strength of a notched bar, be considered also?"

Determine complex properties — 6; simple properties — 2.

The arguments for determination of simple properties only are based on the belief that such simple properties are known and that they lead to a satisfactory prediction of the secondary properties. It is interesting to note that both J.B.F. (for complex properties) and E.M.S. (for simple properties) are leading protagonists of the flow and fracture strength concept of mechanical failure.

[The extensive literature on notch tests in the American metallurgical and welding periodicals indicates the keen interest here in properties revealed by such tests. It has become evident that certain types of notched-bar tests give fracture data not obtainable from the standard tensile test.]

Evaluation of Structural Behavior

(B1) — "What bearing do the yield strength, fracture strength and tensile strength have on the performance of materials in structures? Give examples of satisfactory evaluation of structural materials according to these properties."

Yield Strength — Must be known where plastic deformation of the structure cannot be allowed (S.S.G. and A.M.P.); is important in considering the stability of structures (A.M.T.); must be known in cases of deformation bordering between elastic and plastic ranges (S.B.S.); is possibly significant in counteracting notch action (A.M.P.).

Tensile Strength — Is very important in aviation engineering because it is used in calculations involving structural collapse (A.M.T.).

Fracture Strength — (This is derived from true stress-strain relations and will not conform throughout with nominal tensile strength. However, in the range of interest here, the discrepancy is negligibly small.) Two cases must be noted (A.M.P.), designated brittle and nonbrittle. For brittle materials the fracture strength gives the maximum load-carrying capacity; for ductile materials it must be known for structural components where plastic strain cannot be avoided (S.S.G.).

[In American practice, the properties considered in this question are used in conformance or control tests; thus, the problem here centers on the specifications and whether or not they should be changed. This aspect was not brought into the Russian publication.]

(B2) — "What is the significance of plasticity (ductility) in the normal use of material in construction? What characteristics would you recommend for use in the evaluation of the plasticity (ductility) of structural materials?"

Ductile material is not required in structural elements subjected to static loading, but is required in installations subjected to alternating and dynamic loads (S.S.G.). On the other hand, A.M.P., A.M.T. and J.B.F. contend that ductility *is* required in order to eliminate peak stresses and to minimize notch effects in the structure.

S.B.S. considers ductility as being a capacity for deformation and cold hardening in technological forming processes, while S.S.M. questions the desirability of attaching any general importance at all to ductility. S.S.M. offers some interesting facts in support of his position: notably, that valves for internal combustion engines may be made from either high-chromium steels having low ductility or highly ductile chromium-nickel austenitic steels, and that turbine blades are manufactured from austenitic steels with an elongation of 40 to 50% and also from special alloys with an elongation of 2 to 3%.

(Continued on p. 372)

Movements Among Metallurgists

Hans Ernst

Second only to the names of Taylor and White, pioneers in the scientific study of metal cutting, is that of Australian-born **Hans Ernst** ⊖, for 24 years director of research for Cincinnati Milling and Grinding Machines, Inc., — a fact recognized by the recent award by the Joint Technical and Scientific Societies of Cincinnati of a scroll acclaiming him as "Cincinnati's Outstanding Engineer". The citation notes that beyond his contributions to science and engineering, "he has added to the stature of his profession by his likable personality, and his high ideals and professional ethics".

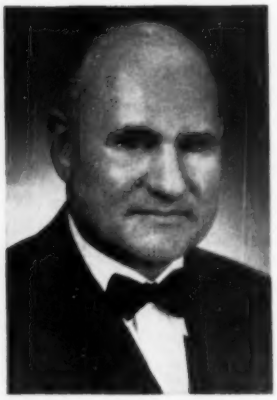
O. J. Richardson ⊖ has been transferred by Minneapolis-Honeywell Regulator Co. from industrial manager of the Detroit office to branch manager in Cincinnati.

C. H. Toensing ⊖, formerly at the Pittsburgh research laboratory of Carnegie-Illinois Steel Corp., is now assistant to the manager of operations of the Brush Beryllium Co., Cleveland.

After returning from nine months in Europe, **Charles G. Aschmann, Jr.,** ⊖ has joined Roberts Numbering Machine Co., Brooklyn, N. Y., as control engineer.

William M. Payne ⊖, previously development engineer at the Tonawanda, N. Y., laboratory of Linde Air Products Co., is now chief mechanical engineer, Speer Resistor Corp. and Jeffers Electronics, Inc., St. Marys, DuBois and Driftwood, Pa.

Karl E. Henrikson ⊖, formerly in charge of the laboratory of the ball and roller bearing plant of Link-Belt Co., is now metallurgist for the Link-Belt Speeder Corp., Cedar Rapids, Iowa.



Zay Jeffries

President of the American Society for Metals was only one of the positions of trust which **Zay Jeffries** assumed during his extraordinarily active and prolific career as teacher, metallurgist, chemist, director of research, business administrator. The Medal for Merit, the highest governmental award for civilians, is only one of the honors bestowed upon this great American. Employees and officials of General Electric's chemical department recently gathered at Pittsfield for a testimonial dinner on the occasion of his retirement as vice-president and general manager of the department. Regret was tempered with a feeling that he will now be relieved of some of the heavier burdens of active life which he has carried for so long.

Albert J. McConnell ⊖, formerly with Nice Ball Bearing Co., Philadelphia, is now a salesman at the Baltimore, Md., office of the Crucible Steel Co. of America.

F. C. Albers ⊖, formerly staff metallurgist in the research department of Caterpillar Tractor Co., is now metallurgist at Chicago Pneumatic Tool Co., Detroit, Mich.

H. Wilbur Keller ⊖ has been transferred from chief metallurgist of the eastern district of H. A. Montgomery Co. to chief metallurgist of the company at Detroit.

Harry P. Croft

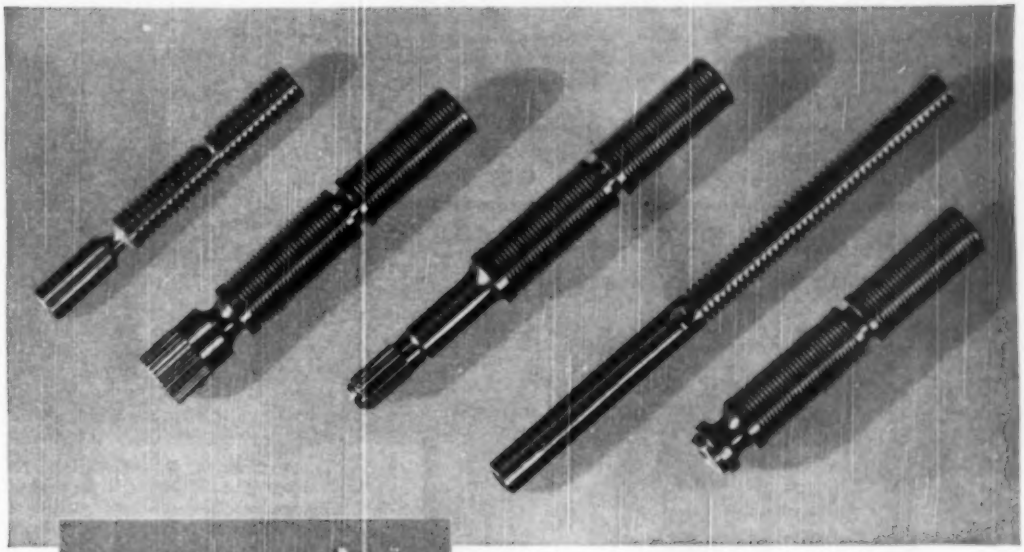
⊖ **Trustee Croft** has been appointed research engineer for Kennecott Copper Corp. at the general offices in New York City. Harry Croft is one of the group of younger metallurgists who have come into the technical direction of the American brass industry. A member of the Chase Brass and Copper, Inc., staff since 1922, he resigned his position of director of technical control and research of Chase's Cleveland operations in 1949 to become vice-president of Wheeling Bronze Casting Co. A reserve officer, he spent nearly four years during World War II as chief of the industrial division of the Cleveland Ordnance District, retiring with the rank of colonel.

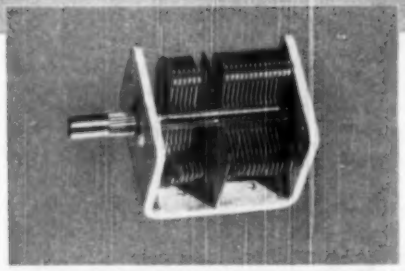
Frank R. McCabe, Jr., ⊖ is now employed by the Jones & Laughlin Steel Corp. at its Aliquippa works in the metallurgical department.

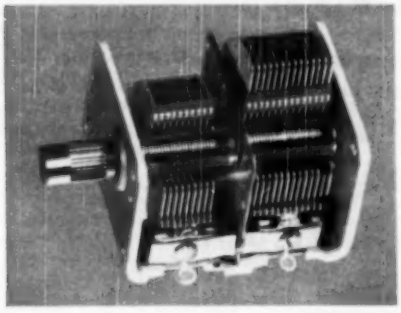
William H. Wise ⊖, a recent graduate of the University of Kentucky, has joined the Electro Metallurgical division of Union Carbide and Carbon Corp. as a production engineer trainee.

John P. Roberts ⊖, formerly chief metallurgical engineer in charge of technical service at the Industrial Testing Laboratories, Houston, Tex., has been appointed associate professor of metallurgy at the University of Houston.

For Tough Machining Jobs, Get REVERE FREE-CUTTING BRASS







Above, Model CS, smallest condenser, air space .009". Below, Model B, largest, air space .013". Rotor shafts, shown in top illustration, are Revere Free-Cutting Brass, plates aluminum. Made by The American Steel Package Co., Defiance, Ohio, an important supplier to the electronics industry.

HERE are several examples of the fact that Revere Free-Cutting Brass is really good. These rotor shafts for variable condensers are cut on automatic machines at 3600 r.p.m. Circular tools are used to cut the concentric slots which are .050" deep. Only one cut has to be taken. Approximately 425 pieces are produced per hour on a 6-second cycle. The American Steel Package Company, Defiance, Ohio, produces a number of different condenser models, with air spacing ranging from .009" up to .042". The slots in the shaft of Revere Free-Cutting Brass are all of the same width, regardless of air spacing, namely .014" plus or minus .0002". It takes good machines, good tools, good men, and good metal to work that closely. A report from a Revere Technical Advisor who had collaborated with the company states: "Customer is outstanding in his praise of Revere Rod." . . . If you have a problem in the machining of brass, why not give Revere an opportunity to work with you? The Revere Technical Advisory Service is at your command

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

Personals

Clark B. Carpenter ⊖, head of the metallurgy department at Colorado School of Mines, Golden, Colo., has been elected national president of Sigma Gamma Epsilon, earth science fraternity.

D. J. Blickwede ⊖ is now a member of the staff of the research department of Bethlehem Steel Co., Bethlehem, Pa. He was formerly in charge of the high-temperature alloys branch, Naval Research Laboratory.

James G. Kerr ⊖, formerly a staff member at the Los Alamos Scientific Laboratory, has joined the C. F. Braun Co., Alhambra, Calif., as research engineer.

Victor H. Bradford ⊖ has been promoted to the position of manager, development and engineering division of Kaiser Aluminum & Chemical Sales, Inc., Oakland, Calif.

A recent graduate of Carnegie Institute of Technology, **Arthur H. Bauman** ⊖ is now in the metallurgical department of the Universal-Cyclops Steel Corp., Bridgeville, Pa.

Donald W. Williams ⊖, formerly associated with Coast Metals, Inc., is now metallurgical engineer in research and development with Thompson Products, Inc., Euclid, Ohio.

Alfred C. Schwarz ⊖, who graduated from the University of Cincinnati in June 1949, has accepted a position with the Texas Co. at its research laboratory in Beacon, N. Y., as mechanical engineer.

Eugene M. Cramer ⊖, formerly assistant metallurgist with the Division of Industrial Research of the State College of Washington, has become a member of the research staff of the Los Alamos, N. M., Scientific Laboratory.

Joseph B. Nusbaum ⊖ has recently organized the West Bay Salvage Co. of San Francisco to buy, process and sell high-alloy toolsteel scrap.

Dan T. Bradley ⊖ is now vice-president in charge of engineering of Harris Products Co., Cleveland.

R. M. Leedy ⊖ has transferred from the materials engineering department of Westinghouse Electric Corp. to the liaison engineering department where he will be doing liaison and materials consulting.

Lynn A. Fill ⊖, chief engineer for Motor Products Corp. for the past 34 years, has been elected president of the American Society of Body Engineers, Inc.

A recent graduate of the State College of Washington, **G. S. Fergin** ⊖ has accepted a position in the division of metallurgical research of the Kaiser Aluminum & Chemical Corp., Spokane, Wash.

Paul M. Leininger ⊖ has resigned his position as senior group leader in the Niagara Falls plant of the electrochemicals department of E. I. du Pont de Nemours & Co. to accept an assistant professorship in chemistry at Lafayette College, Easton, Pa.

John P. Dempsey ⊖ is now a graduate student in metallurgy at Massachusetts Institute of Technology and holds a part-time research assistantship.

P. W. Snyder ⊖, captain in the U. S. Navy, has been transferred from the Philadelphia Naval Shipyard to head the industrial department of U. S. Naval Operating Base, Guam.

Charles I. Geddes ⊖, formerly chief engineer for A. S. Campbell Co., Boston, has been appointed sales engineer for Rollins Engine Co., Nashua, N. H., and will represent the company throughout New England.

FOR LONGER TOOL LIFE, LOWER TOOL COSTS, AND QUALITY HIGH SPEED STEEL HARDENING . . .

Sentry Model "2Y" — For hardening small tools and cutters of moly, tungsten and cobalt high speed steels.

Sentry Model "5Y" — For handling larger tools and cutters. Flexible, economical, quick to heat up.

Sentry Model "YP"—Vertical Furnace for hardening long, slender drills, reamers, broaches, etc.

SENTRY ELECTRIC FURNACES

Sentry Electric Furnaces produce quality hardening, maximum toughness and exceptional durability in high speed steel and high carbon high chrome. Edges stand up longer which means less frequent grindings, longer tool life and lower tool costs.

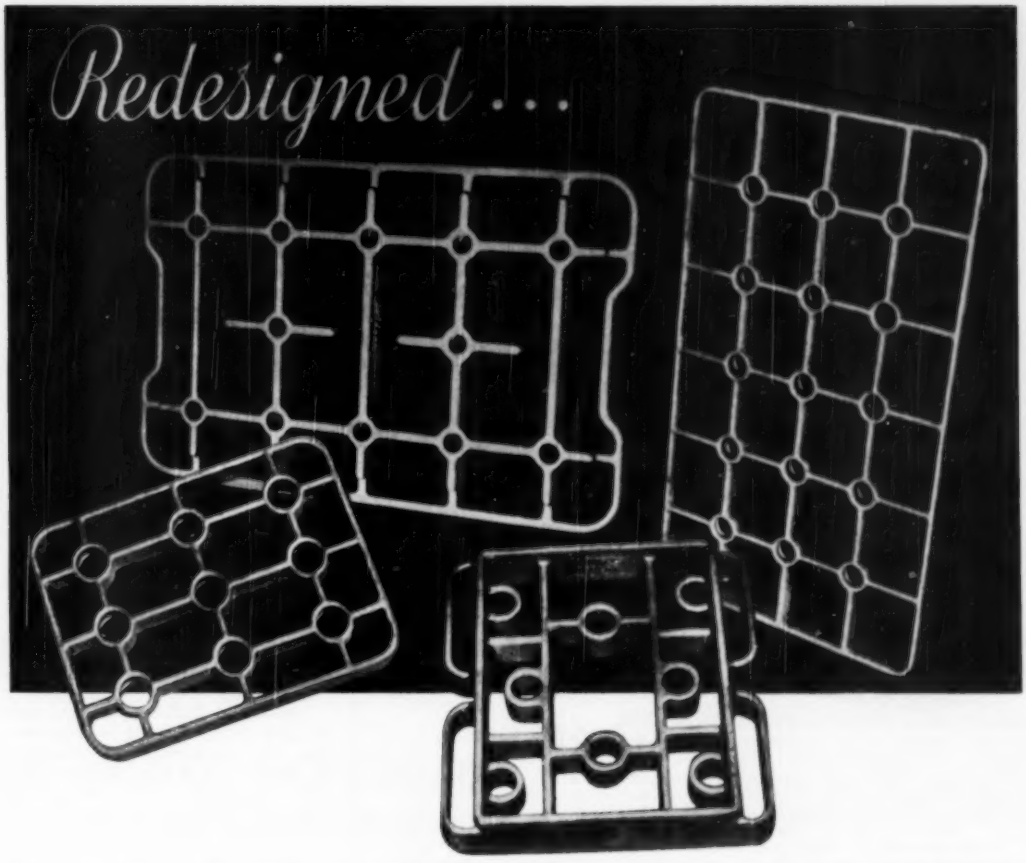
Sentry Furnaces utilize Sentry Diamond Blocks permitting full soaking of tools without danger of burning. No scaling. No decarburization. Produce a clean finish which eliminates finishing operations.

Ask for catalog A17

The Sentry Company

FOXBORO, MASS., U.S.A.

Sentry DIAMOND Block



TO GIVE MAXIMUM SERVICE LIFE!

The gas carburizing trays illustrated above were redesigned by ACCOLOY ENGINEERS to give the ultimate in service for their particular use.

In each of these trays sound fundamental alloy design is incorporated, plus the details of engineering skill and experience that prove their worth in the production line.

It is this engineering skill and casting technique that make these ACCOLOY trays outlast all others. Because our engineers study each individual project and follow each design through its service life, they often improve the customer's product or process far beyond the initial alloy cost.

That is why "Call Your ACCOLOY ENGINEER" is always the advice of so many industrial men who demand highest quality in Alloy Castings.

ALLOY *ENGINEERING* & CASTING COMPANY

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY CASTING CO. (DIVISION)
CHAMPAIGN, ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

Personals

Walter A. Dean has been appointed chief metallurgist of the Cleveland works of the Aluminum Co. of America. He was formerly assistant manager of the permanent mold plant at the Cleveland works.

The Duriron Co., Inc., Dayton, announces that **R. Merton Shields** has been appointed secretary of the company. Mr. Shields was formerly manager of the Dayton district sales; he has been with the company since 1936.

Greswold Van Dyke has been appointed executive director of Stainless Steel Producers, American Iron and Steel Institute, an organization for further development of uses of stainless steel. Mr. Van Dyke was associated for 29 years with Joseph T. Ryerson & Son, Inc., Chicago, where he was manager of the special steel division.

I. R. Jones has been appointed sales engineering representative of Aurora Metal Co. in southern New Jersey, southeastern Pennsylvania, Delaware and Maryland.

A. H. d'Arcambal, past-president of the American Society for Metals, has been appointed general sales manager of the Niles-Bement-Pond Co., West Hartford, Conn. Mr. d'Arcambal was formerly vice-president and sales manager for small tools and gages, and consulting metallurgist of the company.

The Stanley P. Rockwell Co., Hartford, Conn., announces the appointment of **William A. Stumpf** as president, **Dudley W. Rockwell** as vice-president, **Howard F. Baston** as sales manager and **Philip C. Osterman**, president and treasurer of the American Gas Furnace Co., as a member of the board of directors.

Wylie J. Childs, formerly a staff member of the Division of Industrial Cooperation at Massachusetts Institute of Technology, has been named associate professor of metallurgy at Lafayette College, Easton, Pa., where he is in charge of the foundry educational program.

Following graduation from Missouri School of Mines and Metallurgy, **Edward L. AuBuchon** has joined the Wisconsin Steel Works of International Harvester Co. as openhearth metallurgist.

Donald L. Broadbelt, who for the past nine years has been associated with the Bureau of Aeronautics at Philadelphia as a metallurgist, has been transferred to the Bureau of Mines in Pittsburgh where he will have the same rating.

Herbert Kuenzel, formerly at Washington University, St. Louis, Mo., has been appointed head of the department of mechanical engineering at the University of Alabama, Tuscaloosa, Ala.

E. A. Glenn, Jr., formerly with the New Holland Machine Co., is now chief engineer for the Wise Potato Chip Co., Berwick, Pa.

C. B. Willimore is now chief metallurgist of the aluminum alloy division of Kaiser Aluminum & Chemical Corp., Newark, Ohio.

David Lewis, 2nd, has been employed as chief of materials and standards at the Boeing Airplane Co., Wichita, Kan.

Wieslaw Jedrzejowski, formerly with H. C. Evans & Co. and Industrial Tool Engineering and Manufacturing Co., is now design and development engineer with J. L. Ferguson Packomatic Co., Joliet, Ill.

Donald Berman is now a metallurgist at Standard Steel Spring Co., Coraopolis, Pa.

YESTERDAY . . .

. . . . . TODAY!

In the duster and goggles era, automobile body painting was costly, time consuming, and inadequate. Not even a paint system of several coats could retard the formation of bond-destroying rust under the finish.

Today, however, a paint finish of outstanding durability and luster, offering maximum protection against rust, is obtained in a minimum of time and with a minimum expenditure of paint. This is accomplished by treating the sheet steel automobile body with "Granodine" prior to painting.

"Granodine"®

changes the surface of pre-cleaned steel, iron and zinc surfaces into a smooth, crystalline coating of non-metallic zinc-iron phosphate that anchors paint, enhances luster, inhibits underpaint corrosion if the finish is damaged, and adds greatly to paint life and metal preservation.

"Granodine" can be applied by spray, dip, or brush.

"Granodine" protects the paint finish on automobile bodies and sheet metal parts, refrigerator and other cabinets, and, in general, products constructed of cold-rolled steel.

Granodized products are extra-value products. Be sure to tell your salesmen — your distributors — your retailers — and the public that your products are Granodized. Write us for further information.

Pioneering Research and Development Since 1914

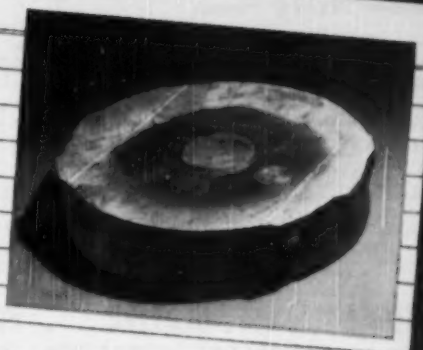
AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

What's the right X-Ray film?

Product:
Cast part for vital aircraft pump
Material:
Aluminum, 2¼" thick, 11¼" diameter
Equipment:
150kv x-ray unit

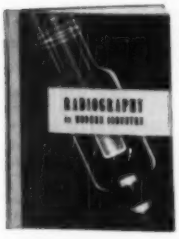


ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE A

With time, money and safety at stake, radiography was used to check this important casting for defects. With moderate kilovoltage to work with, and with aluminum as the material, the radiographer selected Kodak Industrial X-ray Film, Type A.

For with light alloys, this film has enough speed to keep exposures reasonably short even at low voltages. Its high contrast and fine graininess also permit taking full advantage of high kilovoltage machines in detecting irregularities in thick dense materials.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price, $3.

A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. They also provide the means to check welds efficiently and thus extend the use of the welding process.

Type A—has high contrast with time-saving speed for study of light alloys at low voltage and for examining heavy parts at 1000kv. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, under direct exposure or with lead-foil screens. It has extra-fine grain and, though speed is less than in Type A, it is adequate for light alloys at average kilovoltage and for much million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

Radiography...
another important function of photography

Kodak
TRADE-MARK

Personals

H. R. Thomas has been transferred from David Taylor Model Basin in Washington, D. C., to head of mechanical engineering division of the technical department, U. S. N. Mine Countermeasures Station, Panama City, Fla.

Francis L. Shubert, formerly with Combustion Engineering-Superheater, Inc., is now employed at Battelle Memorial Institute, Columbus, Ohio, as a research engineer.

Patrick M. Settanni, formerly with Howard Foundries, Chicago, is now foreman of the annealing department of the Albion Malleable Iron Co., Albion, Mich.

Hans H. Bernhardt has joined U. S. Expansion Bolt Co., York, Pa., as chief engineer.

John C. Southard, director of research of Solar Aircraft Co., San Diego, Calif., has been appointed a member of the subcommittee on Aircraft Structural Materials, a technical subcommittee of the National Advisory Committee for Aeronautics.

The British Steel Founders' Association, Sheffield, England, announces that **J. F. B. Jackson** has been appointed director of research of the recently formed research and development division. He was formerly chief metallurgist and technical controller to David Brown & Sons (Huddersfield) Ltd.

Herbert O. Jarvis has been elected a director of the Continental Copper & Steel Industries, Inc., New York City. He is also a vice-president of the corporation and general manager of the Niagara Falls Smelting and Refining Div.

Harlen F. Mura of the Northeast Equipment Co., Cleveland, has been appointed Ohio district representative for Industrial Furnace Div. of R-S Products Corp., Philadelphia.

Reynolds Metals Co., Louisville, Ky., announces the appointment of **William B. Moore, Jr.**, as a technical service engineer. A graduate of the University of Louisville, he was also employed as chief engineer of the Institute of Industrial Research of that university.

A recent graduate of the University of Pittsburgh, **Frederick A. Settino** has joined the metallurgical department of the Jones & Laughlin Steel Corp.'s Pittsburgh works.

Henry M. Foss has been appointed chemist at Pontiac Motors Div. of General Motors Corp., Pontiac, Mich.

Mike Lauriente, who was formerly associated with Pittsburgh Lectromelt Furnace Corp., has joined the staff of Johns Hopkins University, Baltimore, Md., as a junior instructor and graduate student.

A June 1949 graduate of Case Institute of Technology, **C. E. Hauer** is now in the metallographic laboratory of Bethlehem Steel Co., Johnstown, Pa.

Robert C. Bradley, a recent graduate from the University of Minnesota, has been appointed metallurgical inspector at Inland Steel Co., East Chicago, Ind.

Chase Brass & Copper Co. announces that it has retained **Kemp G. Fuller** as marketing consultant. Mr. Fuller had recently resigned from Chase Brass, where he was manager of marketing, to establish his own business in Pittsburgh.

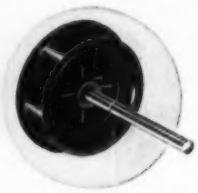
W. L. Schalliol, formerly graduate student and research associate at Stanford University, has been appointed materials engineer at the Sunnyvale, Calif., plant of Westinghouse Electric Corp.

BLACK MAGIC

ECONOMICAL . . ATTRACTIVE . . PROTECTIVE CHEMICAL FINISHES

FOR FERROUS AND NONFERROUS METALS

STEEL



ZINC

CADMIUM

ONE BATH PROCESSES

SIMPLE TO OPERATE — ECONOMICAL TO USE

1. BLACK-MAGIC Processes afford a rich, permanent black finish integral with the metal surface; will not chip, flake or peel.
2. Resistant to heat and thermal shock.
3. No dimensional change.
4. Sales appeal and service life.
5. Optical black finish.

COPPER & BRASS

HEAT TREATING MATERIALS

QUICK-CARB, No. 20—No. 40—No. 60, Liquid Bath Carburizing Salts.
QUICK-TEMPER TEMPERING AND DRAWING SALTS — 375 °F. and 420 °F. Melting Points.
NEUTRAL SALTS — For Complete Range of Temperatures.

METAL CLEANERS

Cleaner No. 7 Still, soak cleaner
Cleaner No. 9 Heavy duty soak cleaner
Cleaner No. 12 Reverse current cleaner
Cleaner No. 20 Non-etching Aluminum Cleaner
Cleaner No. 25 Brass Cleaner (non-oxidizing)
Cleaner No. 30 Etching-type Aluminum Cleaner
Cleaner No. 66 Solvent Cleaner (emulsion type)
Special Cleaners — formulated for specific applications.

PROTECTIVE FILM FINISHES

WITCH-DIP, Wax Base Compound
WITCH-OIL, Water Displacing Corrosion Inhibiting Oil
FINISH No. 146, Hard Protective Coating and Paint Bond
SILCO — An inorganic, low-temperature bake, vitreous-type finish. Rust, acid and abrasion resistant. All colors.

Send for BLACK BOOK

It contains the story of Black-Magic Finishes, also data on all other Black-Magic specialties. Free. Send today.

MITCHELL-BRADFORD CHEMICAL COMPANY
MODERN METAL FINISHES
2446 E. MAIN ST., STRATFORD, CONNECTICUT

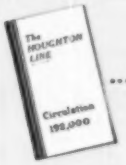
BLACK-MAGIC OXIDE BLACKING SALTS
WITCH-DIP & WITCH-OIL FINAL FINISHES

SILCO Glass-Base PROTECTIVE COATING
HEAT TREATING SALTS, CLEANERS, ETC.

The HOUGHTON LINE NEWS

Published by E. F. Houghton & Co., pioneers in heat treating and metal processing products since 1865

VOL. 18, NO. 1 — MARCH, 1950



...the "near editor's" viewpoint...

Retirement of men at age 65 proved to be a controversial subject, many declaring it is a real social waste. One reason brought forward for today's longer span of life is that we have to live longer to earn enough to pay our taxes.

Since the pendulum swung back from state socialism to free enterprise in Australia, most Conservatives expect to see business improve almost overnight. But the dollar shortage cannot be overcome that rapidly, and that is the fundamental economic problem "down under."

And from Australia comes the item about an old grandfather who was given a new boomerang and spent the rest of his life trying to throw the old one away.

Aaron Harpenter

PRESIDENT.

Photo courtesy Baldwin Loco. Works

Applying Houghton's Cosmoline to exposed moving surfaces of engines to be shipped to India, to prevent corrosion during long ocean voyage. They arrived in perfect condition.

32-Year-Old Oil

We've always said that the only trouble with our treated quenching oil is that it lasts too long—no replacement needed. Here's proof: a New England plant which has used the same quenching oil for 32 years with only small make-up over those years. We checked it for them back in 1940 when new tanks were built and told them it was still O.K. to use, which they did, all thru war production. In 1948 water leaked into the tank and they had to discard the oil. Of course they bought Houghton oil again, because of its proven stability.

Here's a Punch Line

A concern punching lug holes in automobile wheels found it could step up punch life from 25,000 to 100,000 holes per punch—by changing to Antisep All-Purpose Base as the lubricant. Oil consumption was cut to 1/3 that of the former product.

Taking the Bars Down

When you tell a bar mill man he can draw without using lime, he's much interested. That's why the news about a better drawing compound which replaces dirty, hard-to-clean, slower lime, is attracting so much attention.

In one mill we have found over an eight months' period that bars can be drawn faster, with a single dip in a *Houghto-Draw 357* solution. Bars are pickled in a 10% H_2SO_4 solution containing Houghton's *Acitrol* pickling inhibitor. Rinsed, they are then immersed for 5 minutes in the Houghto-Draw solution (5 oz. per gal. of water at 170° F.) drained, dried and drawn. The film is very adherent and prevents rusting. It is readily removed in an alkaline cleaning bath.

Reduction of 1/16" is made on 1-7/16" bars of C-1118 steel, for example, in a single pass, using carbide insert dies. Based on tonnage of ¾" to 1¼" bars which have been drawn, consumption of Houghto-Draw 357 has been about ¾ of a pound per ton of bars processed.

The tank now needs no cleaning, heats up faster because steam lines are not encrusted. Work has brighter finish. Over-all cost is no higher than with lime. Speeds can be as much as 20 ft. per minute faster, with less frictional heat. Either water emulsions or straight oil may be used to cool the dies.

Houghto-Draw 357, a paste-type product containing waxes, fats and colloidal pigment, described in bulletin offered as Item "A" at the right, is one of the new line of proven die lubricants now being announced by Houghton. What is *your* drawing problem?

No Pitting Permitted

Commercial galvanizing shops will be interested in a report from Chicago on the success obtained by one shop using our *Acitrol* Liquid pickling inhibitor, together with our *Cerfak 1300* (synthetic detergent) which provides a foam blanket. Saving of steel was the primary objective; no pitting was experienced; dross was reduced 25%; work came from acid tanks perfectly clean. Details upon request.

The Worm Turns

Steering gear assemblies—worm and roller—have to be carburized to wearproof the tough (5140) steel used. A Detroit manufacturer has long used *Perliton* Liquid Carburizer for this purpose, obtaining an .012" case in one hour at 1525°. Parts are oil quenched and drawn. Hardness of 56-60 RC is obtained. They like Perliton for its speed and dependability. For catalog, circle "C" at the right.

Want to Save $350?

That's what a collet manufacturer estimated he saves in one year by using Houghton's *Antisep* All-Purpose Base at 1:25 with water on a Conomatic. The operations include forming, deep drilling, chamfer, boring and cut-off. Surface speed is 85 fpm; feed .005". A cutting fluid at less than 7 cents a gallon means a real dollar saving, and this water-soluble base will perform as well or better than a straight oil on almost every cutting job. For data, circle "D" on coupon at right.

Sleeves in Salt

Cylinder sleeves and piston rings are isothermally heat treated in salt by a Cleveland manufacturer, at a saving reported to be as high as 15% over other methods. The mechanized series of salt baths includes a preheat in our *Liquid Heat 980*, high heat (1550°F.) in Liquid Heat 168, and quench in Mar-Temp Salt at 450-500°F. It's a faster, surer, modern method of heat treating which avoids distortion. Entire cycle is described in a recent "LINE" article, available on request, Circle "B" in coupon at right.

Here's helpful data—free!

A Houghto-Draw 357 Data Sheet describes compound for bar drawing.

B Isothermal heat treatment of cylinder sleeves and rings covered in Houghton LINE, June, 1949. Copies available.

C Perliton booklet covers products for liquid carburizing.

D Antisep All-Purpose Base—4 p. folder describes this unusual cutting fluid.

E "Handbook on Quenching" contains 60 pages of helpful data on the why and how of quenching.

Mail to

E. F. HOUGHTON & CO.

303 W. Lehigh Ave., Phila. 33, Pa.

Please send me the product literature I have checked below:

A B C D E

Name & Title.....

Company.....

Street.....

City & State.....

3-M

Correlation of Tests*

ONE of the most disconcerting results of the many recent inquiries into steels for welded ship structures has been that the steel which has fractured in service has given evidence of satisfactory strength and ductility according to existing specifications in a normal tensile test. It is now postulated that loss of strength and ductility, which together may result in considerable reduction in energy absorbed to fracture, are all due to the same cause and are covered by the term "notch sensitivity". What is most needed is some clue from the tensile test as to the notch sensitivity of the steel.

The results cover studies of English steel plates for the Admiralty [brittle welded ships are by no means unique to America] with carbons ranging from 0.08 to 0.23%, silicon from trace to 0.11, manganese from 0.23 (C 0.08) to 1.07% (C 1.15). Incidental elements are 0.04% or less except that copper is 0.15 to 0.23 in about half of them; one steel had 0.22% Cr and 0.22% Ni, and nickel ranged up to 0.14% in the others.

Some more-or-less unconventional test pieces were used, in an effort to determine notch sensitivity and the influence of laminations within the plates. The Hounsfield impact and bending specimen is 0.312 in. round. A 45° notch with 0.010 in. bottom radius is ground in, 0.083 in. deep at the diameter. The bottom of the notch, viewed in cross section across the bar, is not flat, but is a curve with 0.698 in. radius. Notches were cut perpendicular to the plane of the plate's original surface.

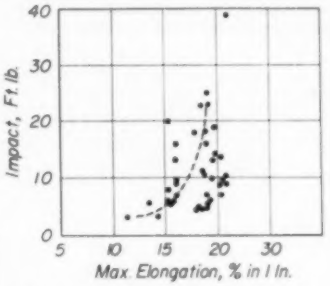


Fig. 1 — One Can Imagine Some Vague Trend in the Relationship Between Maximum Elongation at Tensile Fracture and Impact Energy in the Hounsfield (Modified Charpy) Test

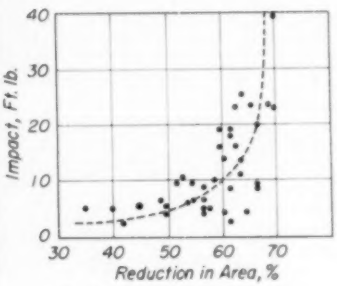


Fig. 2 — High Reduction of Area in Tensile Tests on Ship Plate Is a Better Criterion of Toughness

The Hounsfield modification of the Charpy test uses two swinging arms, one carrying the specimen. Both are released simultaneously. Energy is 48 ft-lb.; striking velocity 22.7 ft. per sec.

Notched tensile test pieces were rectangular, full plate thickness, 1 in. wide, with opposite 45° notches,

(Continued on p. 370)

*Abstracted from "Correlation of Test Results [on Mild Steels for Welded Ship Structures]", by C. F. Tipper, *Welding Journal*, Vol. 29, February 1950, p. 50-s.

Simplify Small Part Carburizing WITH... Park NON-BURNING No. 8 CARBURIZER

1. NO HAND PACKING. Just shovel parts into box with Park No. 8.
2. SAVE EMPTYING TIME. Simply place fine screen over drum and dump.
3. SAVE CLEANING TIME. Seldom necessary to clean Park No. 8.
4. NO PART EXPOSURE BECAUSE OF SHRINKAGE. Low initial shrinkage of Park No. 8 protects parts from exposure.
5. IDEAL for direct quenching.
6. NO BURNING after dumping boxes.
7. NO LARGE REPLENISHMENTS necessary. Park No. 8 can be reused continuously with only moderate additions of new compound.
8. UNIFORM RESULTS. Coke build-up eliminated. Park No. 8 covers all parts.

SEND FOR A TRIAL ORDER

USE PARK "NO-CARB"

...If you want to carburize selectively in either pack or gas carburizers . . . or prevent decarburization on high alloy steels during heating for hardening. Bulletin on request.

Park CHEMICAL COMPANY
8074 MILITARY AVE.
DETROIT 4, MICH.

Nothing takes the place of Chromel Alumel thermocouples

When you're working with heat between 1000° and 2000° F. and accurate temperature measurement is essential to the results you want to produce, you'll find there is no suitable substitute for Hoskins CHROMEL-ALUMEL thermocouple alloys. They're unconditionally guaranteed to register true temperature—E.M.F. values within very close specified limits. Exceptionally durable . . . so resistant to oxidation that you need not pack the protection tube. Hence, highly responsive to temperature fluctuations. And, in spite of hard use, they maintain their fine degree of accuracy over far longer periods of time than any other known base metal thermocouple materials.

So for positive long-life assurance of accurate temperature measurement, insist that your pyrometers be calibrated for CHROMEL-ALUMEL thermocouples. And important, too . . . be sure you use CHROMEL-ALUMEL *extension* leads instead of so-called "compensating" wires. For, when the couple and the lead are of identical alloy compositions there is no possibility of "cold-end" errors. Our Catalog 59-R contains a complete technical explanation . . . want a copy?

CHROMEL-ALUMEL couples and leads are available through your instrument manufacturer or pyrometer service company . . . ask for them by name!

HOSKINS MANUFACTURING COMPANY

4445 LAWTON AVE. • DETROIT 8, MICHIGAN

NEW YORK • CLEVELAND • CHICAGO

West Coast Representatives in Seattle, San Francisco, Los Angeles
In Canada: Walker Metal Products, Ltd., Walkerville, Ontario

**the original nickel-chromium resistance alloy that first made electrical heating practical*

Correlation of Tests

(Continued from p. 368)

⅛ in. deep, bottom radius 0.25 mm. cut perpendicular to plate surface.

The yield stress values give no clue to notch sensitivity; furthermore, ultimate tensile strengths do not correlate well with results of notch tests. However, there is a correlation between total elongation and reduction in area in tensile tests and energy absorbed in notch bend tests, as shown in the accompanying charts. Good ductility insures plastic strain at a notch and hence stress relief at local regions of high intensity; high reduction in area figures indicate resistance to fracture.

In notch bend tests, there is a marked tendency for the energy values in impact to be lower than those in slow bend (see last chart), and the decrease is associated with an increase in crystallinity of fracture.

If the size of specimen is such that a natural notch cannot form before fracture is complete, all the values measured in notch tests will vary with specimen dimensions. Beyond this size, increases in width of plate (as tested) are likely to have less effect on the result and there seems to be no point in

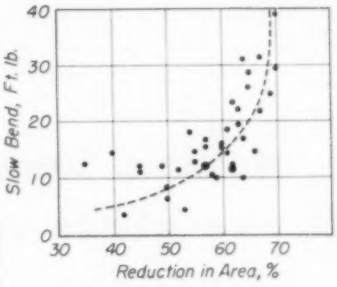


Fig. 3 — Area Under the Stress-Strain Curve in Bending a Notched Round ("Slow Bend Energy to Fracture") Is High for Ship Plate That Has Good Ductility (Reduction in Area in Tensile Test)

increasing the dimensions further. The use of small notched specimens should therefore be confined to such problems as comparing the relative merits of various steels. Full thickness and adequate width are required to judge the behavior

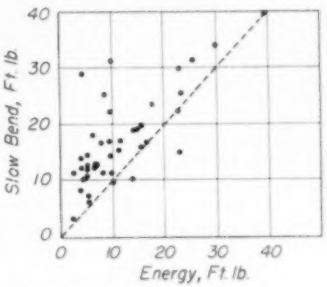
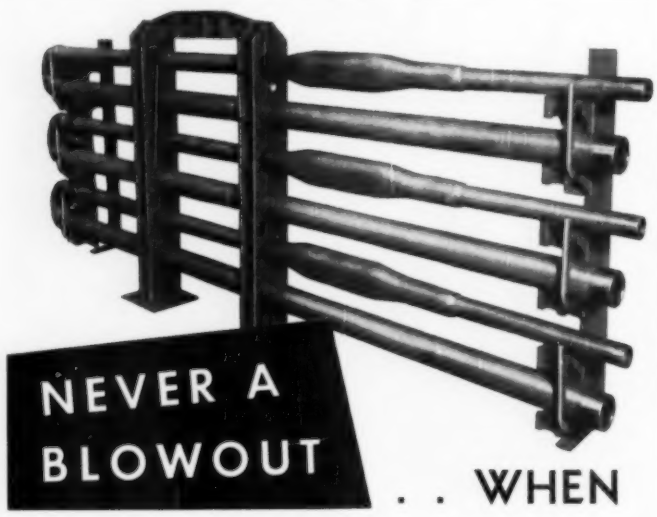


Fig. 4 — Energy Values in Impact Tend to Be Lower Than Those in Slow Bend on Identical Notched Specimens

of material with respect to the full-scale structure.

At the present time, the appearance of fracture is the logical criterion of brittleness to adopt, even though it is only qualitative. If any other criterion is adopted, it would seem necessary to specify the form of test specimen and method of loading.

Transition temperature range (defined as the steep portion of temperature versus impact energy curve, or the temperatures for completely fibrous and completely crystalline fractures in notched tensile specimens) cannot be predicted from ordinary tensile test results.



Combustion Tube Assemblies are engineered by

STANDARD ALLOY

Many extra hours of efficient operation are *engineered* into the radiant tube assemblies we make for leading furnace manufacturers. Years of experience in centrifugal casting of alloy steels combined with modern equipment create *dependable* alloy installations. There's a Standard Alloy Engineer near you—call on him for information on heat and corrosion resistant castings—or write for 24-page data book.

STANDARD ALLOY CO., INC. 1679 COLLAMER ROAD CLEVELAND 10, OHIO

BUFFALO
E. A. Mansfield
Ellicott Square

CINCINNATI
Pearson Browne
1st National Bank Bldg.

PHILADELPHIA
Towle & Son
18 W. Chelten Ave. Bldg.

MINNEAPOLIS
R. E. Hayden
7445 First Ave. So.

PITTSBURGH
Robert A. Schmidt
404 Frick Bldg.

CLEVELAND
C. B. Jackson Sales & Engr. Co.
15201 St. Clair Ave.

CHICAGO
Harry N. Steffen
4821 W. Cortland St.

LONGMEADOW, MASS.
B. G. Constantine
Control Engineering Co.
51 Converse St.

HOUSTON
B. F. Coombs
2221 Telephone Rd.

DETROIT
Gehringer & Forsyth
16151 James Couzens Highway

MILWAUKEE
Ed. P. Lindergren
3748 W. Greenfield Ave.

NEW YORK CITY
R. B. Steele
234 West 31st St.

NEW

. . . with universal case for flush or surface mounting

THE PROTECT-O-VANE EXCESS TEMPERATURE CONTROLLER

HERE'S excess temperature protection in the modern manner . . . with every feature that you would include if you designed and built it yourself. It provides instant shut-down in the event of excess temperature . . . and affords a new high in work-load and furnace protection.

Check these Protect-O-Vane advantages:

- *Reset must be manual and is not effective until temperature drops below safe point.*
- *"Fail-Safe" design . . . flashing signal warns of component failure.*
- *Thermocouple burn-out protection is standard.*
- *Universal case . . . permits flush or surface mounting . . . at no extra charge.*

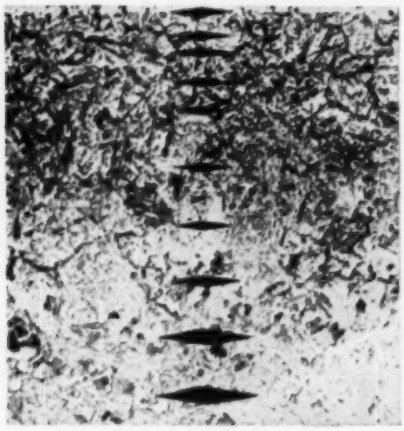
Your local Honeywell engineer is ready to give you more detailed information . . . he is as near as your phone. Call him in, today, or write for a copy of Specification Sheet 113.

COMMERCIAL · RESIDENTIAL · INDUSTRIAL
WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4503 Wayne Ave., Philadelphia 44, Pa.
Offices in 77 principal cities of the United States, Canada and throughout the world

Honeywell — *Advanced Instrumentation* FOR METAL PROCESSING — BROWN

TUKON



X 100 — *TUKON Test on SAE 1020 Steel—Carbonitrided. Load 500 Grams.*

3 MODELS

TUKON TESTER *for* **MICROHARDNESS TESTING**

FOR EVERY KIND OF MICRO-INDENTATION HARDNESS TESTING

Send for

Bulletin DH-114 which contains detailed information about TUKON Hardness Testers. We will also include a copy of our booklet DH-7, which gives the experience of several users of TUKON Testers in different fields.

● The TUKON Tester may be used for testing the constituents of an alloy, thin material, small specimens, small diameter wire and for many kinds of research work—the full range of micro and macro hardness testing. All models may be used with either Knoop or 136° Diamond Pyramid Indenter. Applied loads: Model MO—1 to 1000 grams; Model FB—10 to 3600 grams; Model LR—10 to 50,000 grams.

"ROCKWELL" HARDNESS TESTER

● "ROCKWELL" Hardness Testers and "ROCKWELL" Superficial Hardness Testers were developed and are made only by Wilson for laboratory, toolroom or production line testing.

Write us about any problem you may have involving hardness testing. Our factory-trained Field Service Engineers will be glad to work with you.

WILSON MECHANICAL INSTRUMENT CO., INC.

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

230-F PARK AVENUE, NEW YORK 17, N. Y.

ACCO

Russian Views

(Continued from p. 359)

(B3) — "Please give any information known to you relative to brittle failures of a machine part or structure during operation, while this brittleness was not indicated in testing."

1. Piston rod in a large gas engine. Fracture coarse grained, hence low ductility, due to improper normalizing. (S.S.G.)

2. Cold rolling mill made of forged alloy steel crumbled after about 24 hr. of operation. Probable cause — residual stresses. (S.S.G.)

3. S.S.M. notes that brittle failure is encountered in practice "relatively often", and mentions a piston rod of 1% Cr, 4% Ni, 1% W, 0.18% C (Rockwell C-32 to 40) that failed in a brittle manner despite the "extreme ductility" of the material. Also, crankshafts of Cr-Ni-W steel broke without plastic flow.

4. When forged crankshafts, made of Cr-Ni-W steel and having satisfactory impact strength, fell to a stone floor, several of them broke in a brittle manner. (S.B.S.)

5. A.M.P. has observed no discrepancy between tests and service.

6. The representative of the Shipbuilding Institute (E.M.S.) speaks of the importance of temperature, speed of testing, and notch effect in relation to brittle failures. He mentions a large welded steel structural member that, in a drop test, failed at −10° C. with a brittle fracture, despite a brittle-ductile transition temperature (Mesnager impact) of −60° C.

(B4) — "(a) What is the importance of impact strength as a property of structural materials? (b) How can the satisfactory use of materials with a very low impact strength be explained (for instance, cast-iron crankshafts)? (c) Please give examples of the types of construction which necessitate the use of materials with a high impact strength."

(a) The impact strength is an index of fatigue properties (S.S.G.); it is not (S.B.S.). The impact strength cannot be used as an acceptable criterion in evaluating two steels for a given operation (S.S.M.); the complete curve of energy absorption versus temperature cannot be so used (E.M.S.). The impact strength is sensitive to structure and inclusion count (S.S.M.). It is a measure of notch sensitivity

(Continued on p. 374)

A Lubricant that Works from sub 0 to 3000 plus

ORDINARY lubricants gum up at extremely low temperatures or break down at extremely high temperatures . . . but not Acheson's specially processed **"dag"** colloidal graphite!

This versatile material is dispersed in organic and inorganic carriers for positive transmission to the zone of lubrication . . . for effective concentration at those points . . . for friction-fighting that can't be beat!

"dag" colloidal graphite is unique in its combination of properties and uses. It is very slippery and extremely durable, anti-corrosive, gas adsorbent, chemically inert and, of course, highly resistant to heat.

In deep piercing you get smooth forgings, close tolerances and reduced wear on dies. In casting and mold stripping you get smooth surfaces, clean parting, fewer rejects; and additional mold life.

In forging you minimize scaling and sticking, improve finish, lengthen die life.

In stretch-forming you reduce tearing and rippling. In wire-drawing you get uniform diameter, better finish and greatly extended die life.

Brass, bronze, aluminum, magnesium, carbon steel and stainless steel . . . wherever your fabrication problems are friction and heat . . . **"dag"** colloidal graphite reduces the one and resists the other.

The NEW Acheson Bulletin #426 on the Use of **"dag"** Colloidal Graphite in Metalworking operations is just off the press . . . a copy is ready for you if you will fill in and mail the coupon.

Acheson Colloids is equipped to do custom disintegrating, dispersing, and stabilizing of solids in a wide variety of vehicles. If you are in need of this type of service, tell us about it. We may be able to help you.

ACHESON COLLOIDS CORPORATION
Port Huron, Michigan

☐ Send me the NEW Metalworking Bulletin #426

☐ Send an Acheson engineer

NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE_____

STATE_____

C-18

dag DISPERSIONS

Acheson Colloids Corporation, Port Huron, Michigan

. . . also Acheson Colloids Limited, London, England

2 NEW COMPACT KEMP ATMOSPHERE GENERATORS OFFER PUSH BUTTON STARTING, FOOL-PROOF OPERATION

IF YOU need a compact source of atmosphere gas, *save time and money*, specify Kemp! Two new Kemp Atmosphere Generators (models MIHE-1 and 2) deliver 1000 and 2000 cfh respectively. Both offer all features of larger equipment: push button starting, automatic fire check, flow meter, etc. . . and assure that you get *same analysis* gas from 1% to 100% of capacity.

FOOL PROOF OPERATION

Kemp Generators burn ordinary gas just as it comes from the mains. A famous Kemp Carburetor, part of each installation, assures *complete combustion* without "tinkering" to produce a clean, chemically inert gas containing 88% nitrogen, 12% CO^2 . . . a gas so pure it is used *without further processing* in copper annealing and in the manufacture of *aspirin* and *laboratory chemicals*, fine paints and a host of other products.

WRITE FOR DATA

Whether you need inerts for purging, fire protection, DX, blanketing or any steel application . . . specify Kemp. For technical information write for Bulletin 1-11. *To find out how you can benefit:* Tell us how you produce atmosphere gas now; we'll show you how Kemp can solve your problem. *Mail Coupon today!*

KEMP OF BALTIMORE

ATMOSPHERE GAS GENERATORS

CARBURETORS
BURNERS
FIRE CHECKS
ATMOSPHERE GENERATORS
ABSORPTIVE DRYERS
METAL MELTING UNITS
SINGEING EQUIPMENT
SPECIAL EQUIPMENT

THE C. M. KEMP MFG. CO., Dept. D-3
405 E. Oliver St., Baltimore 2, Md.

Gentlemen: Send me information on Kemp Generators. I am interested in Bulletin 1-11; data on larger equipment.

Name .....
Company .....
Address .....
City ..... Zone ..... State .....

Russian Views

(Starts on p. 358)

(S.B.S. and J.B.F.). Not of much general interest in aircraft construction (A.M.T.).

(b) The cast iron used for crankshafts is alloy iron and has good properties, 120,000 psi. tensile strength with 6.5% elongation (S.S.G.). (Do they make such cast iron in Russia?) It has high damping capacity, high fatigue strength and is insensitive to notches (E.M.S.). A.M.P. contends that high ductility was never required in crankshafts. [Considering the previous remarks on the brittleness of forged alloy steel crankshafts, this statement may have considerable merit.] The majority of the group left this question unanswered.

(c) S.S.G. offers several examples of machine elements that require high ductility, but it must be remembered that he would derive fatigue properties from impact properties, a position unique in this group. No other respondent seems to rely on impact strength; several argue that it can play no part as such a basic criterion.

(B5) — "Where only limited quantities of materials are available for testing, which is preferable: a fatigue test on a polished bar or on a notched bar? Would it not be wiser to test only the notched bar and then to calculate statistically the order of magnitude of the fatigue strength?"

For notched bars — S.S.G., A.M.P., E.M.S. For polished bars — S.B.S. There is no general solution to this problem, according to A.M.T., who would often run the fatigue tests on the actual parts instead of on small specimens.

The second part of the question received scant consideration.

(B6) — "What is the practical significance of creep and high-temperature rupture tests?"

S.S.M. believes that the results of creep tests have practical application, while high-temperature rupture tests probably do not. A.M.T. suggests deeper study to clarify these high-temperature properties. S.S.G., with his usual diligence, has answered this question with a list of structural elements requiring creep and rupture tests and also additional tests. The items on his list range from gas turbine blades to railroad rails. [For what purpose must they employ creep tests on railroad rails in Russia?]

Evaluation of Fabrication Characteristics

(C1) — "Can the forging, rolling and drawing characteristics of metals be predicted by any mechanical tests? If so, give examples. In the evaluation of technological plasticity is it best to imitate, for example, deep drawing operations, as in the (Erichsen) test, or are simple methods of evaluation available?"

The discussion centered largely on the deep drawing properties of sheet metal. This is a very difficult question, and these experts had little to offer. Three of the panel did not report on it; and several of the replies are not pertinent.

(C2) — "In your opinion can the relative machinability of a material be determined from its mechanical characteristics and microstructure?"

This question was left largely unanswered.

Quality Control

(D1) — "Once the testing of a material has been completed, what mechanical properties do you consider as most suitable for demonstrating a deviation from specifications?"

The impact test is most suitable (S.S.M., A.M.P., J.M.P. and J.B.F.). A.M.T. would have more transverse tensile tests on sheet metals. S.S.G. says there is no general solution because, for a given type of material, certain test data are uniquely valuable. Thus, for rivets the yield strength and elongation are important; for welding electrodes, the tensile and impact strengths; for springs, the elastic limit and shear modulus; for piston rings, the hardness; and so on.

(D2) — "Do you share the current opinion that destructive testing measurements (elongation, bending, etc.) furnish a more sensitive index of the change of properties of a material than do nondestructive measurements such as hardness testing?"

With one exception, it was agreed that nondestructive testing is frequently inadequate.

(D3) — "Give examples of the satisfactory application of statistical methods to the evaluation of uniformity and standard quality of metals."

None were advanced.

why wait

FOR STAINLESS PLATE?

• CALL, WIRE OR WRITE

G.O. CARLSON, INC.

- A tremendous stock of stainless steel plates of all sizes and analyses is ready from which your needs can be supplied promptly.
- High speed special equipment for miscellaneous shape cutting can save you time and money, to say nothing of transportation economy.
- G. O. Carlson, Inc. maintains "on time" delivery of heads, rings, discs, forgings, billets, bars, and No. 1 finish sheets.

Save time . . . Call G. O. Carlson, Inc. FIRST
COATESVILLE, Pa. 2800

G.O. CARLSON, INC.

Stainless Steels Exclusively
300 Marshalton Road, Thorndale, Pa.
PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)
District Sales Offices and Warehouse Distributors in Principal Cities

ENGINEERING DIGEST OF NEW PRODUCTS

17-7 PH STAINLESS STEEL: A new precipitation-hardening stainless steel with the strength and hardness of high carbon spring steels and a corrosion resistance closely approaching that of 18-8 stainless has been developed by Armco Steel Corporation. This new alloy, called Armco 17-7 PH Stainless Steel, not only broadens the field of application for stainless sheet, strip, plate and wire but has a unique combination of desirable properties never before available in a stainless alloy.

Excellent corrosion resistance, high strength and hardness, good elastic properties, fabricating flexibility and low-temperature hardenability give the new alloy unusual possibilities. 17-7 PH is especially recommended for use in the chemical, petroleum, textile, aircraft, automotive and food-producing industries. Of particular importance in these fields is the fact that the yield strength in compression is approximately equal to or higher than the yield strength in tension.

The new stainless alloy is available in soft temper strip, sheet, and plate; hard temper sheet and strip; and hard temper and extra hard temper wire.

In the soft temper condition, the alloy can be severely formed or drawn and welded by resistance, metallic-arc, and inert gas shielded-arc methods. After fabrication, its full strength and hardness are developed by heating at 1400° F. for 30 min., air cooling and then heating to 900-950° F. for 30 min., followed by air or furnace cooling. Soft temper sheets when fully hardened have a tensile strength in the range of 185,000 to 205,000 psi., a yield strength of 160,000 to 190,000 psi., and a hardness of Rockwell C40-45.

Hard temper 17-7 PH sheet and strip have fabricating properties equal to Type 301 full hard temper stainless steel. In this condition it can be punched, blanked, flanged and dished to a moderate degree. Tensile strengths over 255,000 psi. and Rockwell hardnesses over C51 are developed by simply heating the metal to 900° F. for one hour and air or furnace cooling. Even higher strengths and hardnesses are possible in very thin gage material.

Hard temper 17-7 PH wire can be wrapped on its own diameter, indicating its adaptability to the manufacture of spring and spring wire products. Typical properties of Armco 17-7 PH wire after hardening are: Tensile strength is 260,000 to 345,000 psi.; yield strength is 250,000 to 340,000 psi.; Rockwell hardness of C50 and up and the proportional limit in torsion is 150,000 to 180,000 psi.

Since only low temperatures are required in the heat treatment of this new alloy, it has additional important advantages. The hardening process is not only simple and economical but cracking, distortion and decarburization, encountered in conventional heat treating, are virtually eliminated. In addition, there is no heavy scale formation to complicate finishing processes. The extremely light scale formed at 1400° F. and the heat tint produced at 850 and 900° F. are both easily removed by a 10% nitric – 1% hydrofluoric acid solution.

For further information circle No. 180 on literature request card on p. 380B

DIE TESTING MACHINE: Lester Engineering Company announces a new machine for testing dies used for casting. The machine opens and closes dies with such accuracy that the parting line can be matched before the die leaves the toolroom.

The operation of the machine is as follows: The two halves of the die are clamped to the two machine platens. The bottom platen moves down and then moves out horizontally. The die is then at a convenient height and out in the open so that it can be easily reached and worked on. It can then be quickly moved in and up, in alignment for checking.

The specifications of this die testing machine are as follows: Locking pressure is 50 tons; minimium die height is 14 in.; vertical die opening is 36 in.; horizontal stroke of die table is 52 in.; machine weight is approximately 15,000 lbs.; over-all height is 112 in.; over-all width is 68 in.; over-all length is 136 in.; it is operated with a 10-hp. motor.

For further information circle No. 181 on literature request card on p. 380B

VERTICAL CONVECTION FURNACE: This furnace is built to perform many types of heat treating operations. According to the Surface Combustion Corporation the work load is easy to handle.

The furnace charge is placed in a removable basket or suspended from a suitable fixture. Furnace construction permits vertical loading and unloading.

A powerful offset convection fan circulates the heated gases, resulting in a uniform distribution of convected heat throughout most loads, even those tightly packed. Heat inputs are up to 650,000 Btu per hour.

For further information circle No. 182 on literature request card on p. 380B

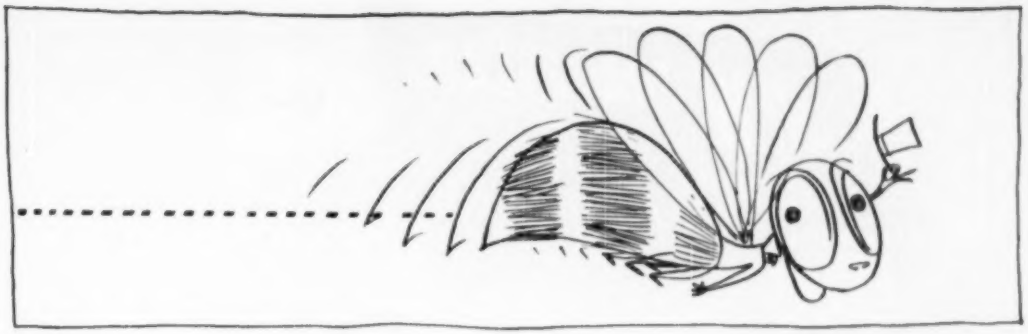
NEW FINISH FOR ALUMINUM: Iridite Alcote, a chromate-type, corrosion-resistant finish for aluminum, has been announced by Allied Research Products, Inc., Baltimore.

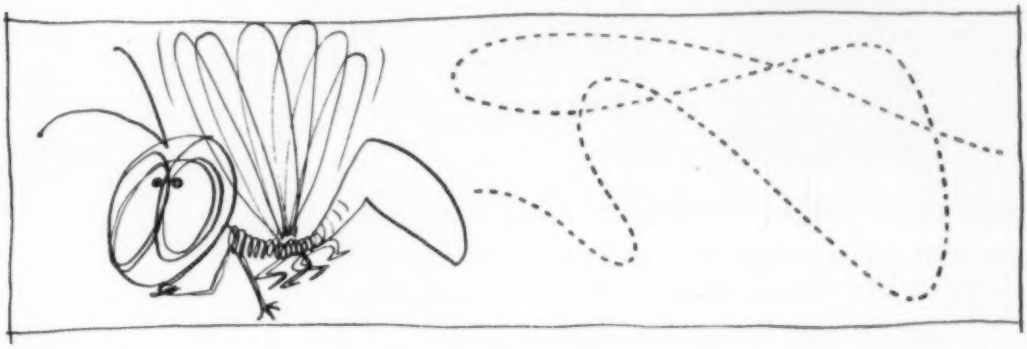
Iridite Alcote is applied to parts by a simple, nonelectrolytic dip with the solution operating at room temperature. No fumes are given off during processing and consequently no exhaust systems are required. The coating ranges in color from clear to light bronze and may be obtained from as short an immersion as 10 seconds.

Salt spray tests indicate resistance to corrosion for as long as 1000 hours on wrought stock and 250 hours for castings, depending upon alloy and treating time.

In addition, the Iridite Alcote coating is highly resistant to abrasion. Treated parts may be buffed, mechanically and roughly handled or formed, without materially affecting the coating.

For further information circle No. 183 on literature request card on p. 380B





Keep oven temperature from jitterbugging

BRISTOL Current Input Controller

keeps temperature on a "bee line"

Practically straight-line temperature control in furnaces, ovens, kilns and melting pots is achieved with Bristol's Electronic Pyrometer Controller.

Motors, depressor bars, toggle switches and contacts are completely eliminated from the control circuit. Control is *all* electronic for greater accuracy and elimination of maintenance.

Since the pointer of the pyrometer unit is free to travel throughout its normal range without mechanical engagement, an accurate indication is obtained at all times, along with closer control of the quantity under measurement.

There's no over-shooting the control point on the start-up. No deterioration of furnace heating elements due to wide temperature fluctuations.

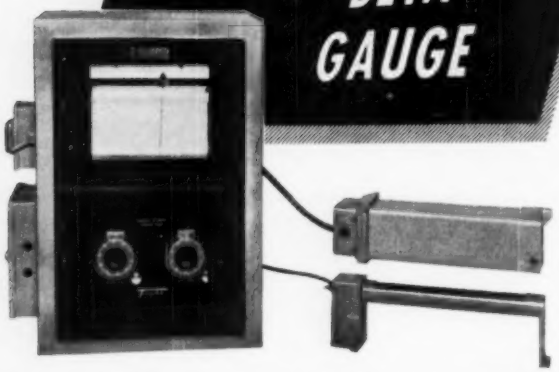
Write for Bulletin PB1237. THE BRISTOL COMPANY, 106 Bristol Rd., Waterbury 20, Conn.

BRISTOL

Gives You the Most from Heat

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

NEW TRACERLAB BETA GAUGE



FOR SHEET STEEL . . . . BRASS . . . . ALUMINUM

ELIMINATE OFF-WEIGHT REJECTS... IMPROVE QUALITY CONTROL
SAVE RAW MATERIALS.... DECREASE VARIATIONS ACROSS SHEET

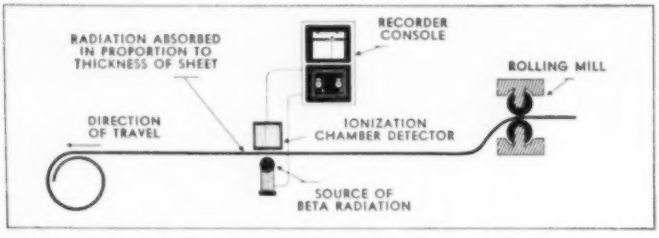
With this new non-contacting thickness gauge

The Tracerlab Beta Gauge is a completely new and unique instrument for measuring and recording thickness of continuous metal sheets directly on the production line. This gauge uses beta radiation from Oak Ridge produced radioisotopes to achieve a high degree of accuracy and sensitivity. It is a non-contacting type of gauge designed for the severe operating conditions usually encountered in production operations.

Another new gauge using beta ray backscattering is also available to measure metallic deposits, such as electrolytic tin plate or galvanized coatings, independent of the thickness of the base material on which they are deposited.

Let us know your problem and we will gladly advise you how Tracerlab Beta Gauges can help you.

Write for Beta Gauge Bulletin MP-20



Tracerlab
INC.
130 HIGH ST., BOSTON 10, MASS.

NEW PRODUCTS

AUTOMATIC TIMING DEVICE: The "Tandem Recycling Timer", manufactured by Industrial Timer Corporation, is a new timing device having unusually versatile features. Two individual timing elements — each able to control a specific operation — are accommodated in a single housing. When the timer dials are set to the respective time intervals required, each cycle of operation will follow the other continuously in regular sequence.

For example: If two successive production operations require 4 minutes and 2 minutes respectively for their completion, the timer dial of one element is set for 4 minutes, and that of the other for 2 minutes. Upon lapse of the 4-minute interval, the first element not only actuates whatever mechanism is necessary to bring the operation it is controlling to an end, but simultaneously actuates the second timing element — in order that the second operation can be immediately commenced. Similarly, upon completion of the 2-minute period, the second element "hands back" the job of control automatically to the first.

In this manner, the sequence can be maintained indefinitely, no adjustments being necessary until new time intervals are required.

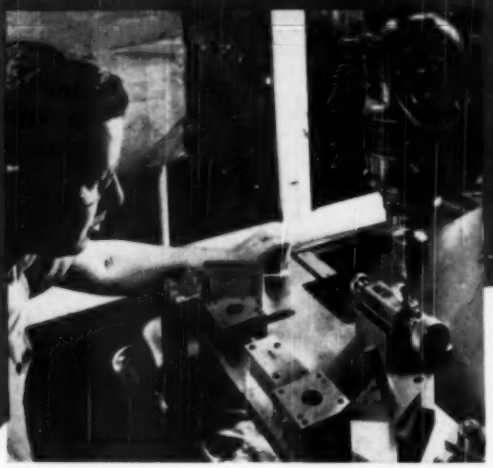
For further information circle No. 184 on literature request card on p. 380B

METAL-CERAMICS: The development of new Metal-Ceramic materials has been announced by P. R. Mallory & Co., Inc. These materials are a mixture of metals and ceramics having unique physical characteristics, especially at elevated temperatures. Mallory is now accepting sample orders for small pieces of Metal-Ceramics in an effort to evaluate major applications.

For further information circle No. 185 on literature request card on p. 380B

BTR

The versatile, safe-hardening tool steel



Long-wearing qualities and easy machinability are important considerations in this accurate locating gage made from BTR for an engine mounting yoke. Made by Lacey Manufacturing Co., Bridgeport, Conn.

This BTR forming die gives dependable service in the production of front wheel housings at the Metropolitan Body Company, Bridgeport, Conn. BTR is safe-hardening, holds accurate size.

1. **Safe** — *Oil-hardens at 1475 F*
2. **Accurate** — *Holds close dimensions in hardening*
3. **Long-Wearing** — *Good wear-resistance for long runs*
4. **Tough** — *Excellent shock-resisting properties*
5. **Easy-Machining** — *Anneals to less than 202 Brinell*

BTR is popular because it combines so many desirable qualities. It's versatile. Veteran toolmakers like it because it performs well in such a wide range of tools and dies.

BTR reduces cracking hazards, for it hardens at 1475 F . . . it's easy to machine and heat-treat . . . it's tough, wear-resisting, deep-hardening . . . and it's a non-deforming steel you can depend on when extra accuracy is important.

Here's an economical grade that belongs in your toolroom. Use it as a general-purpose steel. You'll like the way it saves tooling time, reduces tool failure, prolongs production between grinds.

The nearest Bethlehem Tool Steel distributor or Bethlehem sales office can give you more complete details. Prompt deliveries from local stocks everywhere.

TYPICAL ANALYSIS:

C	Mn	W	Cr	V
0.90	1.20	0.50	0.50	0.20

HEAT-TREATMENT:

Anneal at 1450 F, furnace-cool, 202 Brinell
Harden at 1475 F, quench in oil
Temper from 325 to 400 F for a working hardness of 58 to 62, Rockwell C

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

Export Distributor:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

SUPERSONIC TESTED

Bethlehem Tool Steel

Aircomatic welding process Ups production of home heater units 71%... cuts manufacturing costs

THE STEWART-WARNER CORPORATION, South Wind Division, Indianapolis, Indiana, had a problem joining the upper and lower halves of its "Safe-Air Gas Home Heater". Established methods—bolting, or conventional arc welding were inadequate for today's production demands.

D. P. Carey, Airco Technical Sales Representative, was called in. He suggested the completely new, high speed, inert gas-shielded metal arc method of welding stainless steels, aluminum and other hard-to-weld metals . . . the Aircomatic Process. Two heaters were shipped to the Airco laboratory for test welding. The test was 100% successful, and the company immediately ordered Aircomatic equipment and put it to work on a production-line basis.

As a result, former production of 7 units per hour has been increased to 12 units per hour . . . with an accompanying reduction in production costs.

If you want more information about Airco's Aircomatic Welding Process, write your nearest Airco office for copies of form ADR-53 and ADC-661.

AIRCO **AIR REDUCTION**

Offices in Principal Cities

TECHNICAL SALES SERVICE—ANOTHER AIRCO PLUS-VALUE FOR CUSTOMERS

NEW PRODUCTS

DEGREASING OVEN: An oven consisting of two banks of nine vertically mounted 3.6 Kw. Chromalox Radiant Heaters, each bank with a heater at the base mounted on a 45° angle, to increase the temperature on the bottom edge of the work, is in use at the Lawson Manufacturing Company, Pittsburgh, for degreasing 31 x 20-in. sheet metal parts. Total installed capacity is 72 Kw. The heated section of the oven is approximately three feet long and the conveyor moves at five feet per minute.

During the 36 seconds the parts move between the heater banks, the temperature rises and vaporizes the oil coating. Emerging from the oven the parts proceed to the next operation. An economy factor is the oven's 2-minute heatup time which permits the use of heat only as needed.

For further information circle No. 186 on literature request card on p. 380B

CHRONOGRAPH: A recording Chronograph capable of measuring and recording short intervals of time, 0.033 second or longer, where the interval is approximately known, and where the time can be indicated by the breaking of a circuit, is being produced by Theodore M. Long.

In brief, there is a circular chart, driven at 1800 rpm. by a precision synchronous motor. The breaking of an electrical circuit causes a perforation to be burned in the chart. Two of these marking circuits are provided so that the relative difference in time between two positions of a moving member may be indicated. A single one of the circuits may be used on rotating members to repeatedly make and break a contact so as to indicate the time rate of position of the rotating member. The chart is read by means of a scale marked in milliseconds.

For further information circle No. 187 on literature request card on p. 380B

FASTER-THAN-SOUND MACHINE TOOLS: Machine tools which can be operated at speeds more than 20 times faster than sound and with moving parts that can operate for years without wearing out are about to emerge from the laboratory according to W. W. Goehring, senior antifriction bearing engineer of SKF Industries, Inc.

The value of such speeds in machine tools is that they make possible more efficient grinding of metal parts, which, in turn, produces a finer surface finish.

For further information circle No. 188 on literature request card on p. 380B

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

189. Abrasive Wear
Six-page bulletin, "How to Reduce Abrasive Wear with Thermalloy HC-350", describes the physical properties of the thermalloy HC-350 and lists the many uses and advantages of this exceptionally abrasive-resistant metal. *Electro Alloys Div.*

190. Air Mixers
New bulletins illustrate and describe the complete line of McKee air-gas proportional mixers for all industrial heat applications. *Eclipse Fuel Engineering Co.*

191. Alloy Castings
New 40-page illustrated bulletin entitled "Aluminum Casting Alloys" is an editorial guide for foundrymen. It contains a section on pouring, shrinkage, dross control, solution treating, aging, stress relief, corrosion, test bars, gas absorption and effect of moisture. *Federated Metals Div.*

192. Alloy Castings
New 1950 Reference Chart contains comprehensive analysis of stainless, corrosion and heat resistant alloy castings. Gives Cooper alloy type numbers along with comparative designations of AISI, SAE, ASTM, etc. In addition, lists properties of alloys at room temperature and high temperatures and discusses their applications. *Cooper Alloy Foundry Co.*

193. Alloy Handbook
New pocket-size Alloy Handbook. It's a mine of nonferrous alloy information — and it's yours for the asking. *Riverside Metal Co.*

194. Alloys, Fabricated
New catalog is available, showing cost-cutting fabricated heat treating equipment for higher pay loads and better quality. *Rolock, Inc.*

195. Bars, Forging
There is a stainless steel "tailored" to fit your specifications for chemical and physical properties. Write for 112-page booklet of forging data, "Evaluating the Forgeability of Steels". *Timken Roller Bearing Co.*

196. Blackening Process
New bulletin illustrating and describing the Ebonol blackening process for steel, copper, brass, zinc parts. *Enthone, Inc.*

197. Carburizing-Martempering
Article entitled "Carburizing-Martempering Procedure Streamlines Crankshaft Heat Treating" covers technique employed in combining liquid carburizing and martempering in a single heating operation. The economies effected are compared with the heat treating process replaced. *Ajax Electric Co.*

198. Castings
For complete information on difficult casting problems send for the "Book of Facts" on magnesium, aluminum and bronze castings. *Eclipse-Pioneer Division Fansteel.*

199. Castings
20-page booklet, "Misco Precision Castings", contains valuable technical information for manufacturers requiring small, accurate, alloy steel parts in quantity. *Michigan Steel Casting Co.*

200. Castings, Iron
"Abrasion-Resistant High-Chromium Iron" is a booklet containing the best available information on how to make and use abrasion-resistant iron castings. *Electro Metallurgical Div.*

201. Cerium Metal
New bulletin describes how GCC Mischmetal added in small quantities to many ferrous and nonferrous metals improves metallurgical and mechanical properties of end products. *General Cerium Co.*

202. Combustion Chambers, Graphite
M-9001 describes the graphite combustion chambers and "Karbate" impervious graphite burner nozzles. Outlines operation of the complete system and points out the principal features, such as long life, absence of corrosion, minimum maintenance, ability to withstand thermal shock, simplicity and moderate installed first cost. *National Carbon Co.*

203. Controller
Write for specification sheet 113 illustrating new Protect-O-Vane controller which provides instant shutdown in event of excess temperature and also features Fail-Safe design and thermocouple burnout protection for work load. *Brown Instrument Div.*

204. Corrosion
For membership roster or any information regarding your particular corrosion problems. *American Hot Dip Galvanizers Assoc.*

205. Cutting Oils
For the right combination to suit your specific requirements, write for the booklet, "Cutting Fluids for Better Machining". *D. A. Stuart Oil Co.*

206. Cutting Speed and Feed Selector
A handy, simple-to-use, circular, slide-rule type of Cutting Speed and Feed Selector is yours for the asking. This selector gives recommended feed/speed ratios for eight different stainless steels. *Republic Steel Corp.*

207. Die Blocks
24-page booklet on "Finkl Quenched and Tempered Die Blocks" tells about four types of Finkl die block steel, how to select the right one for your job, how to make your dies last longer, and many other interesting and helpful facts. *A. Finkl & Sons Co.*

208. Die Castings
Revealing book, "How Magnesium Pays", gives case studies of the economical use of magnesium in a wide range of products. *Dow Chemical Co.*

209. Electrodes, Welding
New catalog presents complete line of shielded-arc electrodes for welding of mild steels and alloy steels; gives complete specifications, operating characteristics, mechanical properties, and applications. *McKay Co.*

210. Fasteners
This slide-rule type of demonstrator shows with motion how Rivnuts work. Explains construction, gives proved applications. *Rivnut Div., B. F. Goodrich Co.*

211. Fasteners
Complete file folder contains illustrations and engineering descriptions of fasteners and fittings for resistance welding, adjusting screws, adjustable feet and other products. *Ohio Nut & Bolt Co.*

212. Finishes
New "Black Book" gives full details on black magic finishes for steel, iron, zinc, cadmium, copper and its alloys. *Mitchell-Bradford Chemical Co.*

213. Finishing
New 36-page bulletin entitled "Step Up Production" contains case histories, examples and technical data on grinding and polishing with abrasive belts. *Minnesota Mining & Mfg. Co.*

214. Finishing
Special zinc phosphate coating chemicals provide excellent surfaces for paint-bonding, rust-proofing and drawing. *American Chemical Paint Co.*

215. Free-Machining Bar Steel
Reprint of article entitled "Le-Lad, A New Free-Machining Bar Steel" by Glenn D. Boyer, metallurgist at LaSalle Steel, discusses the advantages and characteristics of the new steel. *LaSalle Steel Co.*

216. Furnaces
72-page Bulletin 116 describes electric salt bath furnaces and their many uses in hardening, annealing, brazing, tempering, quenching, etc. *Ajax Electrothermic Corp.*

217. Furnaces
Bulletin 815-AB gives details for increased production economy with reciprocating furnaces. *American Gas Furnace Co.*

218. Furnaces
Bulletin T-1420 illustrates and describes Lindberg LI-35 induction heating unit. A ruggedly constructed vacuum-tube type of unit for hard working production-line jobs. Ideal for hardening, brazing and soldering, annealing and stress relieving, hot forming and light forging, shrink fitting and other induction heating applications. *Lindberg Engineering Co.*

219. Furnaces
Catalog A-17 illustrates and describes the line of Sentry electric furnaces for high quality hardening to produce maximum toughness and exceptional durability in high speed steel and high carbon, high chrome. *Sentry Co.*

220. Furnaces, Brazing
Fully descriptive folder on furnace brazing, with many suggested "do's" and "don'ts". *Electric Furnace Co.*

221. Furnaces, Lab
Bulletins 315 and 515 describe furnaces for low and high-temperature operation. Five different models for analysis, control and production in chemistry, metallurgy and manufacturing. *Burrell Corp.*

222. Hardness Testers
New information available on the Brinell hardness, transverse, tensile, ductility, compression and hydrostatic testing machines. *Steel City Testing Machines, Inc.*

223. Hardness Testers
Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

FIRST CLASS
PERMIT No. 1361
(Sec. 34.9 P.L.& R.)
Cleveland, Ohio

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY —

METAL PROGRESS
7301 Euclid Avenue
CLEVELAND 3, OHIO

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

224. Heat Treating

Pressed steel lightweight sheet alloy heat treating units furnished in any size, design or specification. Write for full information on this. *The Pressed Steel Co.*

225. Heat Treating

Attractive new booklet, "The Science of Gas Chemistry for Heat Treating". Form 6C-129, gives complete details of applications for prepared gas atmosphere compositions and costs. *Surface Combustion Corp.*

226. Heating Elements, Electric

Bulletin H gives detailed information on AT-type nonmetallic electric heating elements, including tables for a wide variety of sizes available. *Globar Div., Carborundum Co.*

227. Heavy Duty Forgings

16-page booklet on "Heavy Duty Forgings", Profusely illustrated, it shows forgings of all sizes in every phase of development from ingot to finished product. *A. Finkl & Sons Co.*

228. Induction Heating

New bulletin entitled "Typical Results of TOCCO Induction Hardening and Heat Treating" discusses the process with many actual case histories. *Ohio Crankshaft Co.*

229. Lab Furnaces

New pot furnaces for laboratory and research use are described in bulletins HD-635 and HD-546. *Heat Duty Electric Co.*

230. Lubrication of Hot Metals

New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal forming operations. *Acheson Colloids Corp.*

231. Machine Design

Fundamentals of producing low-cost machine parts — design, material and treatment — are discussed in new 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

232. Metal Cutting

New 64-page catalog gives prices and describes complete line of rotary files, burs, metalworking saws and other products. *Martindale Electric Co.*

233. Metal Treating

16-page ready-to-file data folder gives technical information on metal treating and finishing products. *Heatbath Corp.*

234. Microcastings

This 16-page booklet describes many applications for microcasting and also explains the process itself. *Microcast Div., Austenal Laboratories.*

235. Oil Burner

New 24-page catalog 410 describes the Hauck proportioning oil burner. A precision instrument for better combustion, more accurate control of furnace temperature and atmosphere. *Hauck Mfg. Co.*

236. Oils, Cutting

A practical slide-rule-type calculator to help you maintain desired soluble oil concentrations and new bulletin containing information on Gulf Soluble Cutting Oils is available on request. *Gulf Oil Corp.*

237. Oven, Wide Range

Information is available on this new wide-range oven—300° to 2400° F. complete all-in-one furnace. *Sunbeam Stewart Industrial Furnace Div.*

238. Plating

Smooth plating and advantages of Unichrome Copper are discussed in informative bulletin. *United Chromium, Inc.*

239. Plating Generators

For electroplating, anodizing, electrocleaning or electropolishing in either large-scale or small operations, there's a Columbia M-G set available for you. Catalog MP-700 sent free on request. *Columbia Electric Mfg. Co.*

240. Polishing

New bulletin describes advantages in performance of new A8 Polishing Machines in metallurgical laboratory. *Buehler Ltd.*

241. Polishing, Metallographic

For preparation of fine metallographic specimens, a sturdy, smooth-operating table-model metallographic polisher is described in bulletin 90. *Eberbach & Son Co.*

242. Press Forging

Bulletin 75-B explains how many parts can be press forged better, faster and at less cost than by any other method. *Ajax Mfg. Co.*

243. Presses, Powder

Powder metallurgy is being chosen for the manufacture of many products because of the economical high-speed production possible. Send for illustrated catalog showing the complete line of Kux presses available for every phase of this important industry. *Kux Machine Co.*

244. Pressure Vessel Accessories

Valuable reference catalog 9-49 contains 60 pages of important information on pressure vessels, styles and types, and other handbook material. Sent upon request on company letterhead. *Lewis Hydraulic Pressing & Forging Co.*

245. Pyrometers

For the finest results in proportional current-input control send for Bulletin PB1237, which describes the newest electronically operated pyrometer controller. *Brinel Co.*

246. Quenching

"Handbook on Quenching" contains 60 pages of helpful data on the why and how of quenching. *E. F. Houghton & Co.*

247. Ramming Mix

Detailed facts on TAM Zircon grog-type ramming mix available on request. *Titanium Alloy Mfg. Div.*

248. Recorders

Condensed catalog Z6500 gives full description of Capacilog Recorder and other instruments for application in all types of laboratory classification. *Wheelco Instruments Co.*

249. Refractories

New 4-page leaflet No. 312 discusses properties and applications of Taylor Sillimanite (Tasil) special refractories. *Chas. Taylor Sons Co.*

250. Refractories

Complete details on refractory cements for every nonferrous melting operation are available in catalog 865. *Norton Co.*

251. Refractories

New Insulation Chart IN-6D gives recommended insulation for every temperature range from minus 400° F. to plus 3000° F. *Johns-Manville Corp.*

252. Sawing

Bulletin 3-MP illustrates the circular sawing of metals, and new automatic triple-chip method for sawing stock up to 6" accurately without burrs. Write for details on company letterhead. *Motch & Merryweather Co.*

253. Saws

Catalog 49 describes complete line of metal-cutting saws, covering 35 models in 10 basic types, and including the world's fastest automatic production saw, the largest hydraulic hack saws, and some of the most widely used small shop saws. *Armstrong-Blum Mfg. Co.*

254. Spectrographic Outfits

"Spectrographic Outfits for Rapid, Economical Analysis", a scientific and well-illustrated presentation of prism spectrographs by a supplier of both prism and grating instruments. The process of spectrochemical analysis is discussed, along with some of the advantages of prism instruments. The applications for each type instrument are indicated. *Jarrell-Ash Co.*

255. Speedomax Recorder

Information available on the Speedomax recorder that automatically plots the relationship between two variables, showing one as a function of the other. Tedious compilation and manual plotting by experienced personnel are eliminated. *Leeds & Northrup Co.*

256. Spring Wire

Detailed information is available on Pittsburgh spring wire to help solve your coiling, knotting, forming and twisting operation problems. *Pittsburgh Steel Co.*

257. Steel, Alloy

New 32-page brochure, "The Transportation Steel", describing Otiscoloy, low-alloy high-strength steel. Complete technical data, including physical properties of Otiscoloy, are enlivened with stories and excellent illustrations of fabricating operations and finished products. *Jones & Laughlin Steel Corp.*

258. Steels, Alloy

New book is now available on the selection of the proper alloy steel grades for each manufacturer's needs. Write for free copy of "Wheelock, Lovejoy Data Book". *Wheelock, Lovejoy & Co.*

259. Steels, Low Alloy

You can have one-third more production through the use of Hi-Steel, which has nearly twice the working strength of ordinary steels plus the ability to stand up under impact loads. Send for free booklet. *Inland Steel Co.*

260. Steels, Stainless

New bulletin entitled "An Introduction to U.S.S. Stainless Steels", designed to help you get the most out of stainless. *U.S. Steel Corp.*

261. Testing

Simple, accurate, 34-inch-high machine provides speedy testing of tensile strengths up to 20,000 pounds. Literature available. *Detroit Testing Machine Co.*

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

March, 1950

180	200	220	240	260
181	201	221	241	261
182	202	222	242	
183	203	223	243	
184	204	224	244	
185	205	225	245	
186	206	226	246	
187	207	227	247	
188	208	228	248	
189	209	229	249	
190	210	230	250	
191	211	231	251	
192	212	232	252	
193	213	233	253	
194	214	234	254	
195	215	235	255	
196	216	236	256	
197	217	237	257	
198	218	238	258	
199	219	239	259	

Please have literature circled at the left sent to me.

Name _____ Title _____

Company _____

Products Manufactured _____

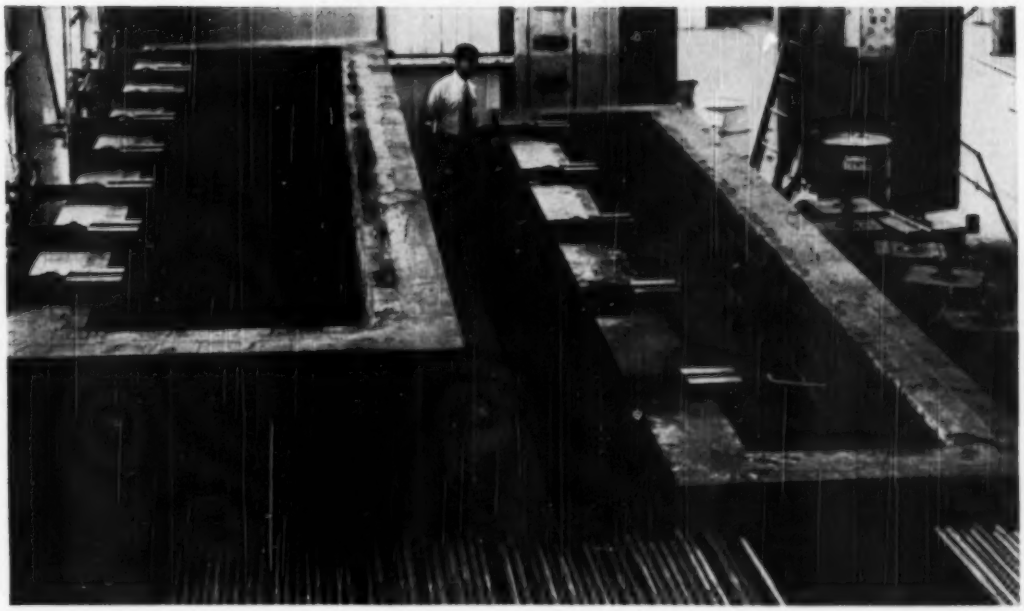
Address _____

City and State _____

Postcard must be mailed prior to June 1, 1950—

Students should write direct to manufacturers.

HOT ACID VS. "KARBATE" IMPERVIOUS GRAPHITE



WHEREVER metals are cleaned, plated or coated, "Karbate" impervious graphite equipment is an ideal material for cooling, conveying, pumping or storing the corrosive fluids involved.

"Karbate" pipe, fittings, valves, plate heaters, steam jets, pumps, tube-bundle heat exchangers, cascade coolers and related equipment are immune to attack by most commercial chemicals. This equipment is particularly well adapted to handling pickling solutions . . . Parkerizing and Bonderizing baths . . . nickel, copper, tin and zinc plating solutions . . . and the Alumilite and Alzek processes.

"National" carbon brick are the time-tested standby in handling nitric-hydrofluoric acid solutions . . . such as are used in the pickling tanks shown above. For complete information on both "Karbate" impervious graphite, and "National" carbon brick, write to NATIONAL CARBON DIVISION, Union Carbide and Carbon Corporation, Department MP.

These products sold in Canada by Canadian National Carbon Company, Ltd., Toronto 4

ADVANTAGES OF "KARBATE" IMPERVIOUS GRAPHITE

- RESISTS THE ACTION OF ACIDS, ALKALIS AND OTHER CHEMICALS
- HIGH THERMAL CONDUCTIVITY
- RESISTANT TO MECHANICAL SHOCK
- IMMUNE TO THERMAL SHOCK
- EASY TO MACHINE AND INSTALL
- LIGHT IN WEIGHT

The terms "Karbate", "National" and "Eveready" are registered trade-marks of

NATIONAL CARBON DIVISION
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
Foreign Department: New York, U. S. A.

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

HY-TEN Alloy Steels are steels with their own specific properties and definitely different chemistry from standard AISI and SAE steels. They are *not* AISI or SAE steels to which a trade name has been attached.

HY-TEN Steels offer the advantages of the latest metallurgical improvements before they are incorporated in the standard groups. The HY-TEN of today is the standard steel of tomorrow.

HY-TEN is a guarantee of uniform chemistry, grain size, hardenability, etc.

HY-TEN *and* STANDARD AISI and SAE Steels are stocked in a wide variety of sizes, shapes, treatments and finishes, thus assuring prompt reliable steel service from WL's seven warehouses.

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

WHEELOCK, LOVEJOY & CO., INC.
134 Sidney St., Cambridge 39, Mass.

Warehouse Service
CAMBRIDGE · CLEVELAND
CHICAGO · HILLSIDE, N.J.
DETROIT · BUFFALO
CINCINNATI

In Canada
SANDERSON-NEWBOULD, LTD., MONTREAL
AJAX DISTRIBUTING CO., LTD., TORONTO

HY-TEN and AISI

Beryllium Control

(Starts on p. 345)

In the typical furnace hood shown in Fig. 3, the high-velocity inlet is located immediately above the opening.

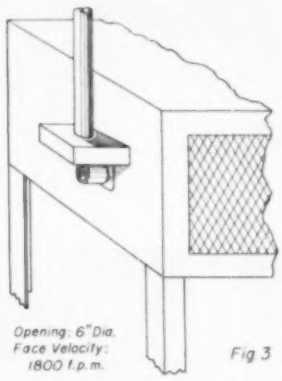
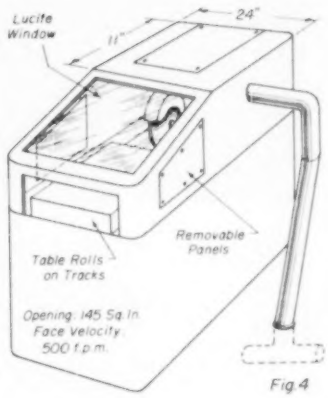


Fig. 3 — Exhaust for Sintering Furnace

Infra-Sizer Hood — Because the gas elutriator, or infra-sizer, is used with powders exclusively, the opportunity for air contamination is great. This hood or enclosure is designed to permit operation with a minimum exposure. The hood has both inner and outer doors. Face velocity is 135 f.p.m.



Cut-Off Wheel Hood (Fig. 4) — The cut-off wheel throws a fine beryllium-bearing mist and this hood has a high face velocity, 500 f.p.m. Removable panels facilitate the cutting of objects too long to fit in the hood. Another removable section provides access to the abra-

(Continued on p. 384)

BIG SAVINGS IN CARBURIZING TIME

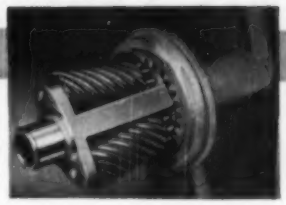
with AEROCARB® E AND W easy washing carburizing compounds

Here's What Experienced Heat Treaters Say:

Good for intricate parts

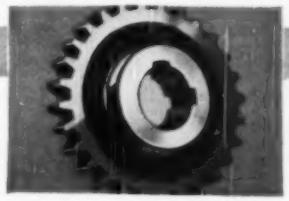
"These intricate business machine parts which have been carburized in AEROCARB E and W Compounds and oil quenched are easily cleaned without washing machinery or chemicals."

Saves time—eliminates finishing



"In carburizing the blades of pencil sharpeners to a depth of .015 inches, the use of AEROCARB E and W Compounds has resulted in a 29% saving in operating time over a competitive salt. These compounds give the blades such a bright appearance after carburizing that no further finishing is necessary."

Rapid penetration of spline gear



"Thanks to the rapid penetration of Cyanamid's AEROCARB E and W Compounds, we carburized spline gears to a case depth of .030 inches with a 16% saving in processing time compared with former treatment."

And Here Are 4 More Advantages Offered by AEROCARB E and W Carburizing Compounds:

- Flexibility: wide temperature range, 1300° F – 1750° F.
- Close-Control: time-tested two-component principle used.
- Low Viscosity: bath is watery—low drag-out losses.
- Efficiency: maximum penetration at low cyanide concentration.

Treat metal with Salt Baths to treat metal right

To meet all your needs—Cyanamid offers a *complete line* of quality-controlled salt bath products. AEROCARB Carburizing Compounds and AEROCASE® Case Hardening Compounds for liquid carburizing and heat treating of metal parts, for producing a hard, wear-resisting case. AEROHEAT® Heat Treating Compounds for superior salt bath hardening, annealing and tempering of carbon and alloy steels.

Consult your Cyanamid Technical Service representative on any heat treating or carburizing problem in your plant.

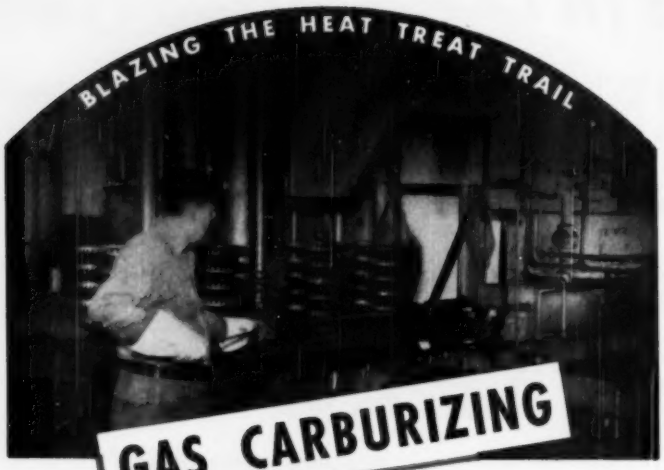
DISTRICT OFFICES:
Boston • Philadelphia • Baltimore • Charlotte • Cleveland
Chicago • Kalamazoo • Detroit • St. Louis • Los Angeles

MP 3-50

AMERICAN Cyanamid COMPANY
Industrial Chemicals Division
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

☐ Please send me technical data sheet on AEROCARB E and W Easy Washing Compounds.
☐ Send data sheet on Cyanide disposal.
☐ Have a Technical Service representative call.

Name _____ Position _____
Company _____
Address _____
City _____ State _____



Developed by Holcroft in 1935 for

MORE ACCURATE, LOWER-COST CASE HARDENING

HOLCROFT engineers established the basic principle on which *all* modern gas carburizing furnaces operate—namely, that in order to control the process, a non-decarburizing gas must be used to dilute the hydrocarbon gases which supply the carbon for carburizing. In order to *apply* this principle, Holcroft & Company in 1935 designed and built a generator to produce such a diluting gas.

This patented development—resulting from original Holcroft research—brought all the advantages of today's gas carburizing process. These include (1) accurate control of case depth and carbon content; (2) exceptionally clean, soot-free work; (3) a notable increase in furnace alloy and tray life; and (4) greater output with much less labor. Because of these advantages, gas carburizing is rapidly replacing pack carburizing throughout industry.

Further details on the process are given in the Holcroft Gas Carburizing bulletin, available on request.

The Holcroft engineering leadership which developed gas carburizing is available to serve YOU in production heat treat work of every kind. And remember—Holcroft offers you COMPLETE METALLURGICAL AND ENGINEERING SERVICE, from designing the furnace to your individual needs through the trial run in your plant. We invite your inquiries.

SINCE 1916 **Holcroft AND COMPANY**

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

6545 EPWORTH BLVD. DETROIT 10, MICHIGAN

CHICAGO 3
C. H. MARTIN, A. A. ENGELHARDT
1017 PEOPLES GAS BLDG.

CANADA
WALKER METAL PRODUCTS, LTD
WALKERVILLE, ONTARIO

HOUSTON 1
R. E. McARDLE
5726 NAVIGATION BLVD.

Beryllium Control

(Starts on p. 345)

sive wheel. The unit is illuminated from within.

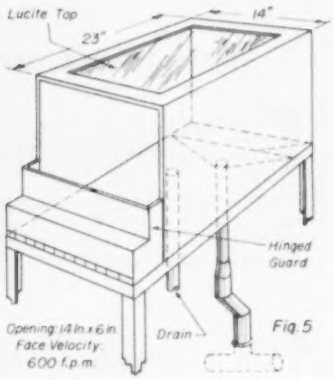


Fig. 5

Belt-Polisher Hood (Fig. 5) — The belt polisher projects particles at high velocity. Most of these are thrown to the rear of the hood and into the exhaust duct. A guard traps the particles that may be thrown from the endless belt as it travels toward the operator, and a high face velocity (600 f.p.m.) retains dust that may arise from the belt surface. The operator exposure during the belt polishing operation is 0.06 γ per cu.m.

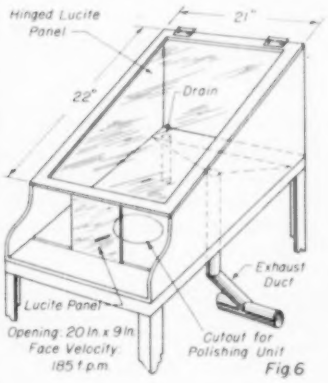
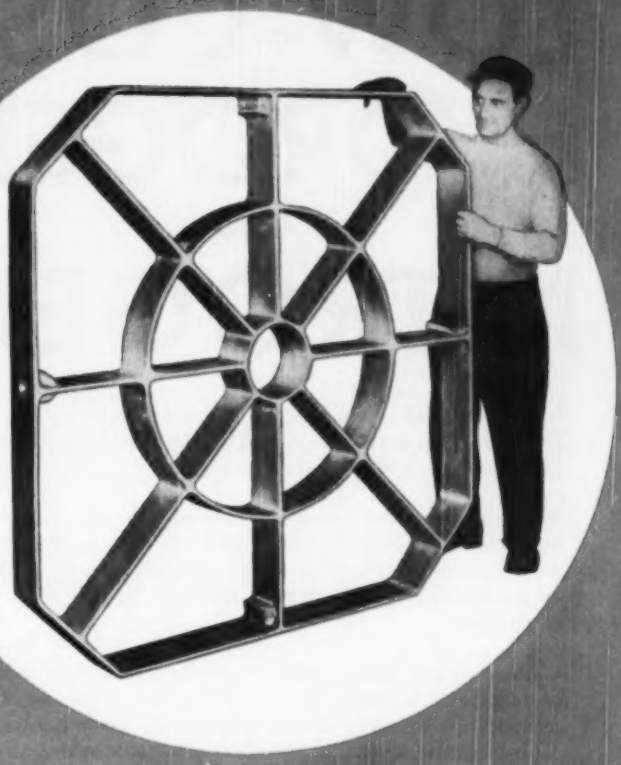


Fig. 6

Wet Polishing Hoods (Fig. 6) — Another operation likely to throw particles of beryllium is wet polishing. The sliding lucite panel protects the operator from particles thrown toward the front of the hood. Operator exposure during this operation is 0.07 γ.

(Continued on p. 386)

650-lb. Furnace Part poses the "$64 Question"



When Wright Aeronautical Corporation decided to install a large roller batch furnace for heat-treating turbo-jet engine assemblies and other parts, the furnace base plate presented unusual manufacturing difficulties.

Required to provide a surface area of more than 30 square feet, it had to be as light as possible, yet capable of delivering a long life of dependable service, without distortion, at operating temperatures of 1700° - 1800° F.

Final specifications called for a base plate of intricate shape, cast in Nichrome — because Nichrome is superlatively resistant to heat and corrosion at high temperatures.

Since nickel-chrome alloys have a high rate of shrinkage, however, actual production of the base plate called for exceptional foundry know-how. Only the most precise compensations and controls could prevent a casting of this shape and size from being ruptured completely in the mold—at as many as 24 different places.

Here, at Driver-Harris, we produced this 650-lb. furnace part without flaw — another example of the outstanding ability of our foundries to take care of tough jobs!

We have had more than 36 years' experience designing, fabricating and casting furnace parts and fixtures, and as makers of world-famous Nichrome*, Chromax* and Cimet*, we are prepared to help solve YOUR heat-treating problems with equipment unsurpassed for dependability, efficiency and economy.

FIFTIETH ANNIVERSARY — SPECIAL PURPOSE ALLOYS SINCE 1890 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Nichrome, Chromax and Cimet are manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

* T. M. Reg. U. S. Pat. Off.

LOW-COST HYDROGEN AND NITROGEN

YOU effect real economies when you use Barrett Standard Anhydrous Ammonia as a replacement for other more expensive sources of hydrogen and nitrogen.

Barrett Standard Anhydrous Ammonia (Refrigeration Grade) contains a minimum of 99.95% NH_3 and is oxygen free with a very low dew point. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and help of Barrett technical men are available to Barrett customers without charge. For information, contact Barrett, *America's leading distributor of ammonia.*

Barrett*

STANDARD ANHYDROUS AMMONIA

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N.Y.

*Reg. U. S. Pat. Off.

Beryllium Control

(Starts on p. 345)

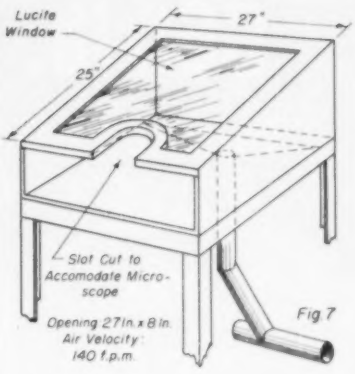


Fig. 7

Microscope Hood (Fig. 7) — The microscope may be inserted in the slot shown so that the specimen is completely inside the hood. During the dry polishing of specimens on abrasive paper within this hood, the operator exposure was measured as 0.20 γ per cu.m.

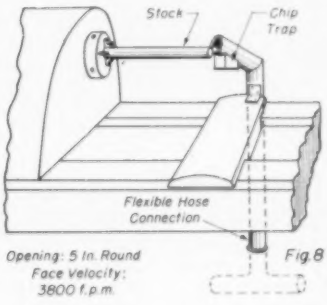


Fig. 8

Lathe Exhaust (Fig. 8) — Lathe turning is a particularly difficult operation for which to provide adequate ventilation because of the complexity of controls and adjustments. It appears most practical to place a high-velocity duct as close to the cutting tool as possible so that all dust and fine chips made in turning will be drawn into the exhaust system. The duct is attached to the tool carriage and maintains its position relative to the cutting, regardless of the location of the tool in relation to the lathe bed. A chip trap is placed in the duct so that most of the metal entering may be recovered before it reaches the plenum chamber of the dust collector. The operator's exposure was measured as less than 0.20 γ per cu.m. *(Continued on p. 388)*

for *"every job in the shop"*

—this versatile cold work Tool Steel!

NON-SHRINKABLE COLONIAL NO. SIX

Specially annealed for easy machining • Hardens with minimum distortion and size change • Hardens without danger of cracking even in the most intricate designs

In addition to die steel uses such as blanking, forming and trimming, this versatile steel is good for taps, reamers, broaches, gauges, bushings, mandrels, rolls, cams, shears, lathe centers and many other jobs that tool rooms are called upon to supply in a hurry.

Of course you can't carry a supply of all the special tool steels that are designed to give maximum performance on each specific application (that's why we maintain warehouse stocks in principal manufacturing centers), but you *can* have a general purpose tool room stock and be sure it's a wise investment—just specify:

NON-SHRINKABLE COLONIAL NO. SIX

OTHER FIRST QUALITY Die Steels for Cold Work

CROCAR

OHIO DIE

AIR HARD

COLONIAL NO. 4

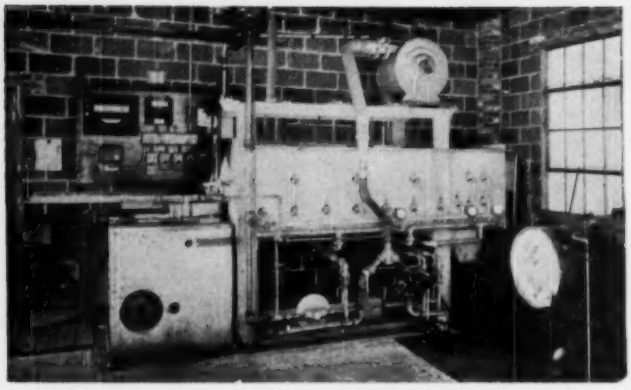
RED STAR TUNGSTEN

FIRST QUALITY TOOL STEELS

Vanadium-Alloys STEEL COMPANY

LATROBE, PENNA.

Colonial Steel Division **Anchor Drawn Steel Co.**



RECIPROCATING, CONTROLLED ATMOSPHERE FURNACES

SUITED TO WIDE RANGE OF GENERAL AND ATMOSPHERE WORK

VERSATILE. A.G.F. Reciprocating Furnaces are suited to continuous clean hardening, annealing, normalizing, case-hardening by the patented Ni-Carb process, etc. Work treated in the same furnace may range from extremely small light springs, stampings, drop forgings, etc., up to quite large and heavy pieces.

THE RECIPROCATING MUFFLE advances work through the heat by its own momentum. Heat losses and maintenance problems are reduced to a minimum by the complete elimination of conveying mechanism from the heating chamber. There is no traveling belt to be alternately heated and cooled — only work enters and leaves the furnace.

Write for Bulletin 815-AB today.

AMERICAN GAS FURNACE CO.

1002 LAFAYETTE ST., ELIZABETH 4, N. J.

ROCKWELL FURNACE-OF-THE-MONTH

Ready for Shipment to a Large Steel Wire Mill

Double-Decked Continuous Bright Hardening, Quenching and Drawing Furnaces for Strip and Flat Wire

This unique Rockwell design integrates two furnace units, one above the other, in a single compact mounting, with each pair of hardening and drawing furnaces operating independently of the other pair. The metal is heated while moving through the muffles of the hardening furnaces, thence through quench blocks, drawing furnaces and cooling tubes, always in a protective atmosphere, to emerge ready for coiling. Furnaces are gas fired, with zone control of temperature.

Rockwell builds continuous and batch furnaces, electric or fuel fired, for all wire heating operations.

ROCKWELL ALSO BUILDS { *Coil winding machines, reels and spools; pickling, brushing, cleaning, washing, finishing, drying and handling equipment; ovens and dryers; special fabrications; non-ferrous rod mills.*

ROCKWELL SINCE 1888 BUILT

FURNACES · OVENS · SPECIAL MACHINERY

W. S. ROCKWELL COMPANY

204 ELIOT STREET · FAIRFIELD, CONN.

In Canada: Francis Hankin & Co., Ltd. Montreal & Toronto

Beryllium Control

(Starts on p. 345)

This is not the optimum design for a lathe exhaust, but is adequate (as evidenced by air analysis) if the cutting operation is kept within the capture zone of the high-velocity duct and if small material is being turned. The use of coolant is important.

Surface-Grinder Hood — During the surface grinding of a bar, a large amount of metal is removed and thrown at high speed. A large quantity of coolant is used to wet the beryllium particles and flush them into the coolant tank where they may settle out. In addition the operation is completely enclosed. All controls are located outside the hood, and operations proceed normally although the work is inaccessible. The grinder is always flushed and cleaned after use. Exposure is less than 0.20 γ per cu.m.

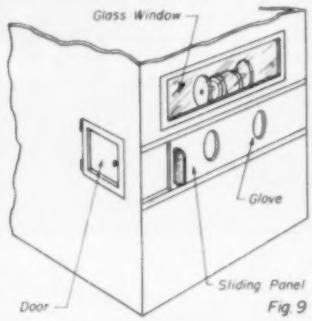


Fig. 9

Bench-Grinder Hood (Fig. 9) — The bench grinder has been installed on a shelf inside the infrasizer hood; all dust produced is thereby taken into the exhaust of that system. Two glove holes on a sliding panel permit manipulation at either wheel. A door at the side is opened for insertion of specimens.

General Construction — Most of the operations in which powder is used — for example, mixing and compacting — are concentrated on the first floor area. Walls, floor and ceilings are smooth with generous coping, and a continuous coat of acid resisting paint is applied. The interior is constructed so that it may be completely washed by hosing, and permanent floor drains have been installed. The floor is of red asphalt composition, covered with gray, acid resistant paint. Thus, a dust-catching crack developing in the paint is obvious because of the color contrast between paint and base. *(Continued on p. 390)*

There's a Story...

BEHIND THESE GALVANITE CONVEYOR ROLL SPACERS OF INTEREST TO EVERY STEEL FABRICATOR

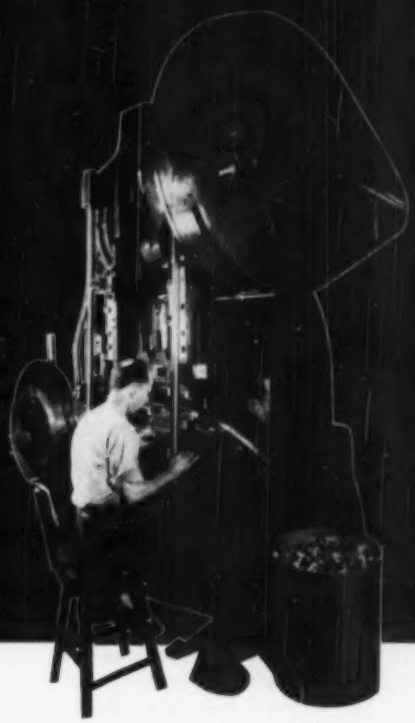
THE spacer tubes pictured on this page were Superformed* directly from coils using a progressive die on an OBI press. The National Formetal Division Federal-Mogul Corporation believes this method gives them better concentricity in their product—faster at lower costs.

The metal used in this operation is important. It must be uniform of gauge and hardness, and must be able to take the severe forming without breaking or scarring. Because conveyors are often used in the open, the steel must be weather-resistant.

To conform with these specifications National Formetal found **Galvanite** ideal. By using Galvanite they were able to discard the coating operation—a move that saved time, speeded delivery, and cut more than a cent and three-quarters off each pound of finished spacers.

If you are manufacturing a product that is subjected to the weather it will pay you to check with Sharon — sole producers of **Galvanite.**

*Trade Mark of National Formetal



SHARON STEEL CORPORATION

Sharon, Pennsylvania

DISTRICT SALES OFFICES: Chicago, Ill., Cincinnati, O., Cleveland, O., Dayton, O., Detroit, Mich., Indianapolis, Ind., Milwaukee, Wis., New York, N. Y., Philadelphia, Penna., Rochester, N. Y., Los Angeles, Calif., San Francisco, Calif., St. Louis, Mo., Montreal, Que., Toronto, Ont.

IF IT'S IRON OR STEEL

REMEMBER to have it HOT DIP GALVANIZED

(DIPPED IN MOLTEN ZINC)

Only HOT DIP Galvanizing provides the heaviest practicable coating of zinc *inseparably bonded* to the steel. For the longest-lasting economical rust prevention, specify "Hot Dip Galvanizing" done by a member of the American Hot Dip Galvanizers Association. List of member plants available by writing to the Association's headquarters in the First National Bank Building, Pittsburgh 22, Pennsylvania.

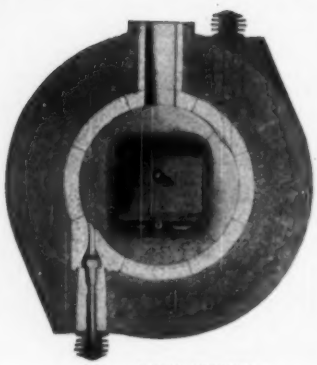
The Inside Story!

"Durability"

THE "DELAWARE" CONTROLLED ATMOSPHERE FURNACE

has a combustion chamber lining made from heavy blocks of CAST MULLITE.

- Mullite is rated with the best of refractory materials in its resistance to heat and abrasion.
- With the use of Mullite the necessity for frequent relining is eliminated.



Range, 1200°-2800°F.

Descriptive Literature on Request

DELAWARE TOOL STEEL CORP.

Wilmington, Delaware

Beryllium Control

(Starts on p. 345)

Personal Protective Services

All personnel who regularly work in this building on either a part-time or full-time basis are assigned dust and fume respirators and all are trained in the proper use of them. A program of routine washing, sterilization and repair of respirators has been established. These respirators are faithfully employed in operations such as the cleaning of apparatus after use, cleaning of hoods, disposal of contaminated rags or papers, cleaning up of minor spills, repair and disassembly of equipment, and in the routine janitorial work. Respirators are used also at the time of initial air-testing of new operations or changes of procedure in which the extent of exposure is unknown. The removal and cleaning of electrostatic precipitator plates are also done by personnel wearing these respirators.

When a large quantity of beryllium powder is spilled — for example, by breakage of a stock jar — airline respirators are worn. All are trained in the use of this type of device. The airline respirators are employed also in the cleaning of enclosures such as the infra-sizer where a man must enter.

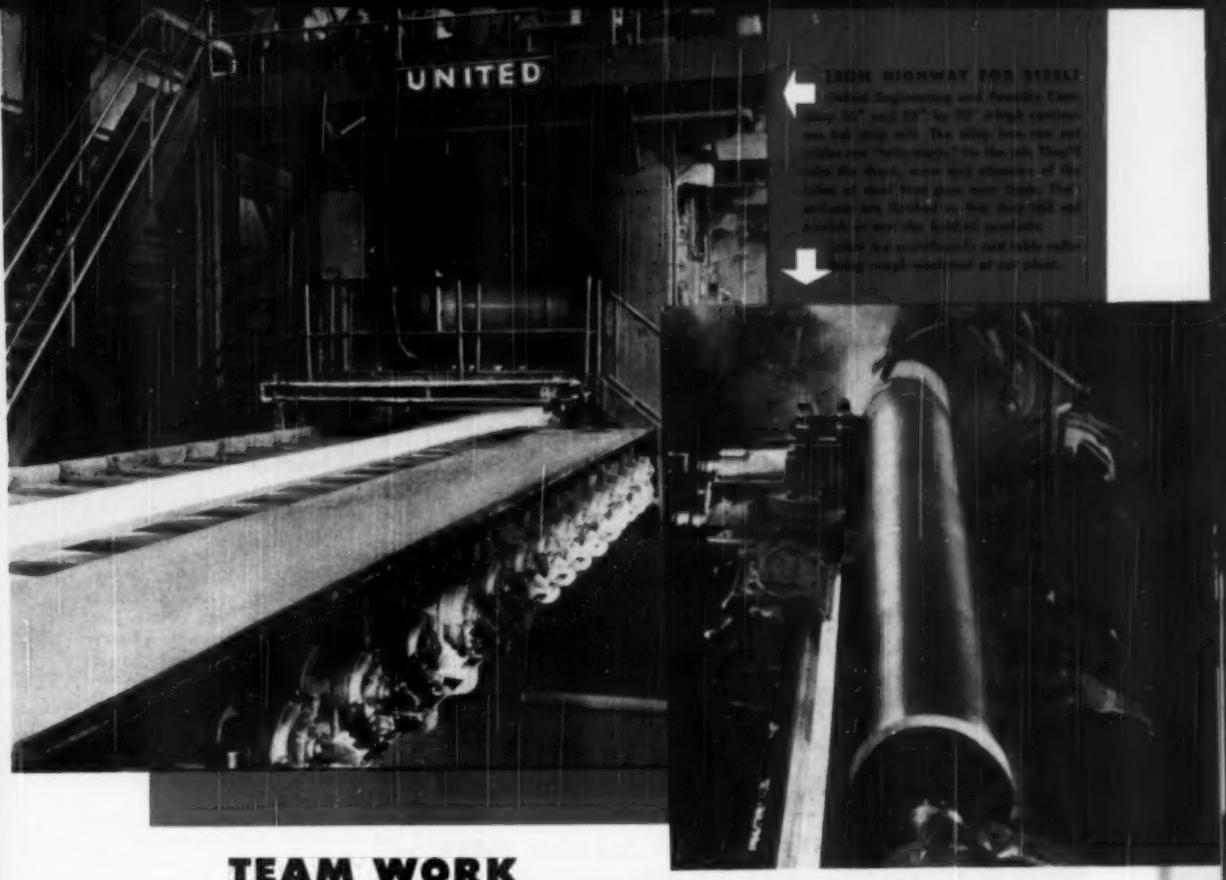
Workers are encouraged to develop unusual personal cleanliness. Hand washing after every beryllium-handling operation is urged, and daily showers are compulsory.

Cleaning Facilities

In order to remove traces of atmospheric dust, the ventilation system is in operation 24 hr. a day. The areas are swept nightly with ordinary sweeping compound. The floors are mopped twice weekly, and the first-floor area is given a complete hosing and washing weekly.

For general cleaning of equipment or clean-up of spills a cylindrical case-type vacuum cleaner with replaceable cloth filter bag is employed. The outlet of the cleaner is connected to the exhaust system.

Rags are available which, wetted, are used in wiping after any beryllium handling operation; all benches, hoods, tools, equipment, and materials are cleaned immediately after use. The used rags and other contaminated waste are disposed of permanently by burial at a remote site. *(Continued on p. 392)*



TEAM WORK IN ACTION!

Cooperation built these run out rollers for a steel mill. One of the world's greatest industrial specialists, United Engineering and Foundry Company of Pittsburgh finished them. U. S. Pipe and Foundry Company supplied the rough machined castings.

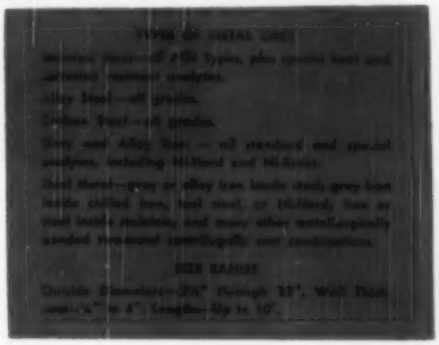
And that's how we like to work. Our job, as we see it, is to make the finest centrifugally cast tubular products industry has ever known. But we furnish those products "as cast" or rough machined for others to finish and to fabricate.

Teamwork, however, is only half the reason why more and more fabricators today ask us to help with their casting problems. "Quality" is the rest of the answer.

Fabricators and builders know, for example, that "centrifugally cast in metal molds" means rough castings of a high order . . . castings that simplify *their* job of finishing. They find, too, that our unique mold coating process permits the casting of longer length tubular products with a tight, dense grain structure remarkably free of voids, non-metallic inclusions and other defects.

We don't know . . . *yet* . . . your casting requirements. But whatever they are, we'd like to show you how teamwork and centrifugal casting "know how" can help solve them.

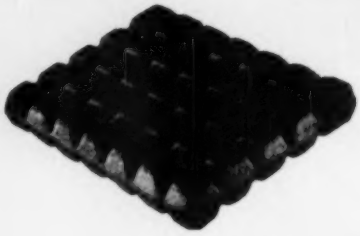
Write today and let's talk over *your* specific problem.



U. S. PIPE AND FOUNDRY CO.

SPECIAL PRODUCTS DIVISION — BURLINGTON, NEW JERSEY

AMERICA'S LARGEST PRODUCER OF CENTRIFUGALLY CAST FERROUS METAL PRODUCTS IN TUBULAR FORM



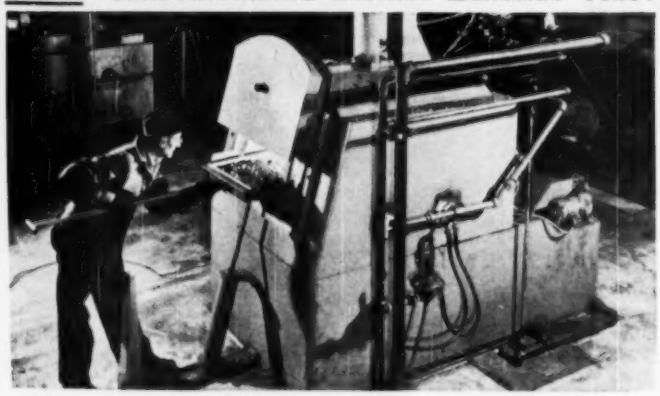
A Little Does a Lot

GCC CERIUM METAL (Mischmetal) added in small quantities to many Ferrous and Non-Ferrous Metals improves the metallurgical and mechanical properties of the end products.

Discover how a little does a lot by writing for our informative bulletins.

GCC GENERAL CERIUM CO.
EDGEWATER. NEW JERSEY

NOW CARBONITRIDING *another Lakeside* FIRST



CARBONITRIDE—GAS CARBURIZE—CLEAN HARDEN SMALL PARTS WITH PRODUCTION LINE EFFICIENCY

• This furnace produces controlled case characteristics, bright and clean work on low carbon steel. Perhaps this step forward in making carbonitriding available on small metal parts in this territory will help you solve an old production problem. Why not call your Lakeside metallurgist today?

Our Services: Carbonitriding, Electronic Induction Hardening, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Sand Blasting, Tensile and Bend Tests.

*Approved Steel Treating Equipment by U. S. Air Force—Serial No. DE-S-24-1 through 30.

THE *Lakeside Steel Improvement Co.*

3418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

Beryllium Control

(Starts on p. 345)

Work Clothing—Each person regularly working in the building is provided with work clothing, including shirt, trousers, laboratory coat, cap, shoes and socks. Fresh clothing is provided daily for workers who use the building continuously; those whose use is less frequent are supplied with three changes per week; infrequent users of the building whose stay is less than one-half hour are given clean laboratory coats.

Medical Control

All facilities and operations are subject to the approval of the medical director. Frequent checks are made by members of the medical and safety section to observe and evaluate new operations, changes of process and general environmental conditions.

Each man is provided with an instruction manual on health and safety practices and is responsible for adhering to provisions set forth in the manual.

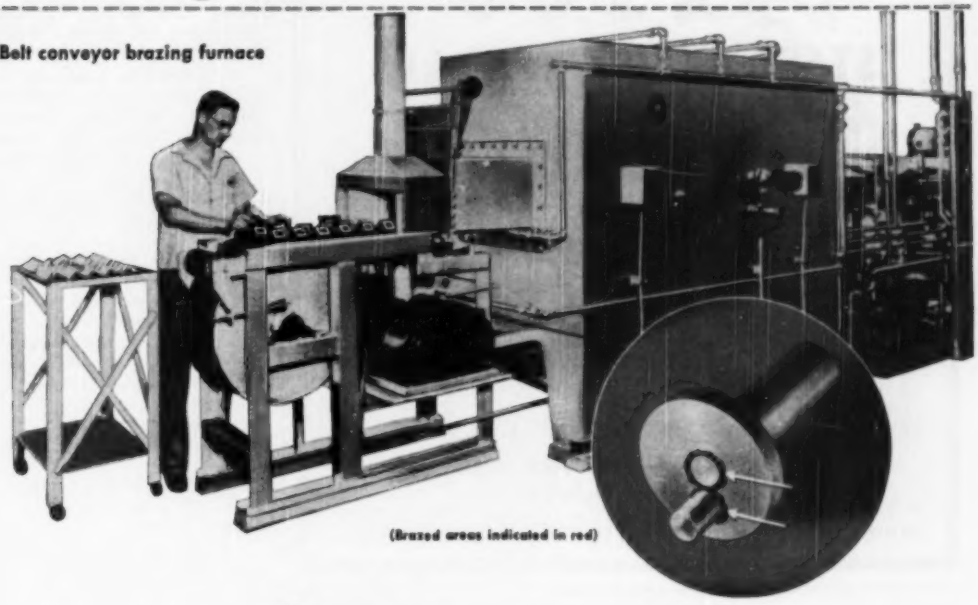
The health program is administered by the medical director and is supervised by the plant physician and a resident registered nurse. Each employee is given an initial, complete medical examination. Thereafter, medical consultation and monthly checks are made for weight, vital capacity, breath holding, and general health. Periodic examinations, including a chest X-ray, are given semiannually, and urinalyses are made regularly.

Continuous air-sampling units are located in the approximate center of each room at a point about seven feet above the floor. Each unit has its own meter and is operated from a central pump. General air concentrations are taken over the entire working day. A portable sampler is used to determine workers' exposures in various operations and to measure the efficiency of exhaust control. New operations or changes in procedure are evaluated by this instrument, and no operation is approved until an atmospheric beryllium concentration of less than 1.0 γ per cu.m. can be maintained. The sampling and analysis are also supervised by the medical section.

The worker's exposure during any operation is less than 1.0 γ per cu.m. His usual exposure is far less than this, as is his over-all daily exposure.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



Belt conveyor brazing furnace

(Brazed areas indicated in red)

$1,120 SAVED

every 8 working hours with Westinghouse Brazing

Four cents per unit! $1,120 every eight hours. That's what one manufacturer saved when he switched from machining to Westinghouse brazing. With production of 3,500 units per hour, each furnace produced these startling savings.

Why spend dollars? Braze it for pennies with Westinghouse equipment. The Westinghouse brazing furnace is only one of a wide variety of furnaces—both gas-fired and electric—produced by Westinghouse.

For either gas-fired or electric operation, Westinghouse can make thorough, impartial recommendations for the type of equipment needed to handle your heat-treating problem most economically. Get all the facts today. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, 181 Mercer Street, Meadville, Pennsylvania. J-10347

Therm-a-neering. A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

Westinghouse

GAS AND ELECTRIC

Furnaces

IMMEDIATE DELIVERY

52100

STEEL TUBING and BARS

PETERSON STEELS, INC. maintains the largest stock of high carbon-chrome (52100 type) steel, seamless tubing and round bars in the country. More than 200 sizes of tubes from .875" O.D. to 8.231" O.D. Bar stock from .171" round to 7.5" round.

Ring forgings also supplied quickly — any analysis, any size.

WRITE FOR CURRENT STOCK LIST

Contains full information on all available sizes, finishes, etc. Write today, on your business letterhead, for your copy.

PETERSON STEELS, INC.

Dept. B, 420 Lexington Ave. • NEW YORK 17, N.Y.

Telephone: MUrray Hill 5-1560

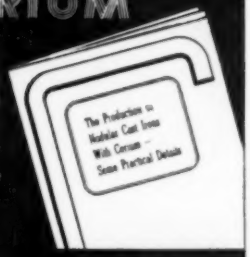
NEWARK, N. J. • DETROIT, MICH. • CHICAGO, ILL.

News . . . . about

"The Production of

NODULAR CAST IRONS"

with CERIUM



New booklet describes in detail actual foundry methods as practiced by members of the British Cast Iron Research Association.

For the first time, available in the United States.

Sent upon request

CERIUM METALS Corporation

Pioneer and Largest Producer Cerium and Cerium Alloys

153 WAVERLY PLACE • NEW YORK 14, N. Y.

Metal Cleaning

(From p. 340) scale remains in loosely adherent form on the surface of the work and is blasted from this surface by quenching in water. A short acid dip brightens the surface and leaves a fine matte finish. The operations are briefly:

1. Preheat in furnace at 800° F.
2. Sodium hydride dip; temperature 700 ± 20° F. The concentration of sodium hydride may be as low as 0.5% but in practice varies from 1.3 to 2%. Time varies from a few seconds to 30 min., depending on the condition of the original material.
3. Water quench. The work coming directly from a bath at 700° F. generates steam which blasts the loose material from the surface.
4. Acid dip; 12% sulphuric to neutralize any remaining caustic; then nitric-hydrofluoric acid dip as a brightener.
5. Cold water rinse.
6. High-pressure spray water wash.
7. Hot water rinse and dry.
8. Polish to bring up to a high luster if required.

The smooth surface produced by sodium hydride descaling and pickling is easy to keep clean. It takes a high polish and can be used for simulated finishes.

Tests for Cleaners

A simple test for both chemical and physical cleanliness of steel or iron has been recommended by George B. Hogaboom (35th Annual *Proceedings*, American Electroplaters' Society, 1948, p. 215). This test consists of a copper sulphate dip, 5 oz. copper sulphate, 1 fluid oz. sulphuric acid, and water to make one gallon. At room temperature the resultant coating of copper should be clear, semibright, of good color, free from spots and strongly adherent to the steel. If the slightest film of oil, grease, soap, oxide (visible or invisible), or colloidal substances from the alkaline cleaners should be on the steel, the copper coating will be dull or nonadherent. If the formation of the copper coating is slow, it is also an indication that the surface of the steel is not entirely clean.

Specifications for cleaners are under consideration by the A.S.T.M. Committee D-12, Sub-Committee II, Section G. An important element in their work is the investigation of

(Continued on p. 398)

GENERAL ELECTRIC FURNACE SAVES BETTER THAN 30% ON OPERATING COST

AS REPORTED IN

Electrified INDUSTRY*

"Better than 30% saving on operating cost, rejects cut to a minimum, greatly improved working conditions and quality of product are all attributed to the use of a roller hearth electric furnace for cleaning hollow ware prior to enameling. This new and revolutionary method being used by the Republic Stamping and Enameling Company in Canton, Ohio, bright anneals the parts to produce clean, bright surfaces resembling aluminum. Stresses due to forming and welding are gone, original grain structure is restored, and blue-oxide from spot welds has disappeared with the new process."

*"New Cleaning Method for Hollow Ware Has Many Advantages" in ELECTRIFIED INDUSTRY, March, 1949.

General Electric builds electric furnaces and associated equipment for practically every industrial heat-treating process. For more information on G-E furnaces or on G-E induction or dielectric heating equipment, consult the nearest G-E Apparatus Sales Office; or write to: *Apparatus Dept., Sect. 720-10, General Electric Company, Schenectady 5, N. Y.*

ELECTRIC FURNACES

ANNEALING • BRAZING • DRAWING
CARBURIZING • ENAMELING • HARDENING
NORMALIZING • SINTERING

GENERAL ELECTRIC

Plan to Show Your Products . . .

to thousands of

'KEY' CONTACTS

when the

METAL INDUSTRY

meets at the

METAL SHOW

in

CHICAGO!

Floor Plans Now Available
from
American Society for Metals
7301 Euclid Avenue
Cleveland 3, Ohio

NATIONAL METAL CONGRESS *and* EXPOSITION

October 23-27, 1950

INTERNATIONAL AMPHITHEATRE • CHICAGO

Sponsored by

AMERICAN SOCIETY FOR METALS • AMERICAN WELDING SOCIETY
A.I.M.E., METALS BRANCH • SOCIETY FOR NON-DESTRUCTIVE TESTING

"There is NO SUBSTITUTE for EXPERIENCE"

and no alloy experience to compare with G A

Experience in pioneering in metallurgy of Nickel-Chrome and Chrome-Nickel Alloys.

●

Experience as the originator of the greater part of the alloy furnace mechanism in service today.

●

Experience in the largest and most complex castings, and in precision parts for gas turbines.

●

Have you seen the ten-ton eighteen by twenty-four foot stainless plaque by General Alloys on the Associated Press Building at Rockefeller Center, N.Y.?

●

Offices:

Baltimore
Boston
Buffalo
Chicago
Cleveland
Dayton
Detroit
Fort Wayne
Houston
Indianapolis
Los Angeles
Milwaukee
Muncie
New York
Philadelphia
Pittsburgh
St. Louis
Tulsa

"MISFITS"

unnecessary ~ wasteful ~ costly ~

EXPECTED!

Engineering, Design, Metallurgy, and Casting of two-score highly diversified and complex alloys is not a simple business.

It is becoming increasingly evident that he who seeks to understand and control the functional efficiency and ultimate economy of Heat and Corrosion Resistant castings must embrace and effectively control the *inter-related application* of many arts and sciences.

Knowledge, acquired from 32 years' experience, and from Research and Development, is enabling us to evaluate much of the ignorance from which "misfits" are born.

More evident becomes the fact that the production of complex alloys is a full-time job for a trained technical organization, not a sideline for a "foundry".

"Misfits" are to be expected in proportion to the experience and competence of the buyer, for he who buys on "first cost" and keeps no service records of life economy or functional value will find suppliers to his liking; those who can always "make it a little bit worse and sell it for a little bit less".

If you agree that no "economy" is factual that is not *reflected in your operating costs* and in the quality of your product, — *if you keep records on the life of your alloys in service*, you will understand and approve G.A. policy. Our Prime Objective is *the service life* of our product, extending the interval between service interruptions on your job at *a lower unit cost of service rendered.*

Engineered Alloys!

No furnace is better than its Alloy Parts

GENERAL ALLOYS COMPANY — BOSTON

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

This sample TEST

lets you determine the DRAWING QUALITY of SHEET METAL

Use it for receiving, inspection and quality CONTROL

DUCTILITY
TESTING MACHINE
Model PA-2

THOUSANDS of dollars of scrap material can often be saved by making this simple cup test. A flick of a switch operates machine. Speed of piston travel is adjustable within a wide range by simple dial setting. Load is applied automatically and uniformly to grip the specimen, followed immediately by penetrator to form cup. Pressure is accurately shown on large gauge with maximum indicating hand; depth of draw shown on depth indicator. Hydraulically operated. Model PA-2 has 15,000 lb. capacity for stock up to 3/8" thick; Model PA-3 has 30,000 lb. capacity for stock up to 1/4" thick. Write for literature.

***Give Us Your* TESTING PROBLEM**

We have a thirty year record of solving testing problems for leading industries in America. We have a full line of Brinell hardness, transverse, tensile, ductility, compression and hydrostatic testing machines. We can produce the machine you need. Write for information on our entire line or send us details of your problem.

Steel City Testing Machines Inc.

8035 LIVERNOIS AVE. • DETROIT 4, MICH.

Metal Cleaning

(Starts on p. 339)

analytical methods and performance tests which they have broken down into the classifications listed and detailed below.*

pH and Titration Values — Methods and equipment are readily available and satisfactory. Titration of alkaline or acid solutions is an old, standard method for estimating strength of solution. Another indication of relative strength of alkalinity is measurement of hydrogen-ion concentration (pH). Although neither titration nor pH values is a complete index of utility, a combination of the two is highly useful. In addition, the determination of the buffering action is of great value. A highly buffered material remains at nearly its initial pH value over a considerable range, either upon the addition of acid or alkali to it, or upon dilution. Such information can be determined readily by titrating a standard solution of the mixture with a standard solution of acid or alkali, measuring the pH values at given intervals of addition.

In general, there are two systems available for pH measurement, colorimetric or potentiometric. The glass electrode system has proved most readily useful because it may be used under a variety of conditions.

Colloidal Properties — Tests are available but are highly specific in character. Methods for measurement of colloidal dispersion of soil or its adsorption and peptization (deflocculation) are to be found in Federal specifications. Investigators in the detergent field have also tested the deflocculating action of soaps, alkalis and wetting agents against carbon black.

Water Softening — Methods are available for soap or soapless compositions, but tests in the presence of synthetic foaming agents have not been developed. One important performance test in alkaline solutions is their resistance to decomposition by the hard water elements. Hard water should be softened through their use, and the amount of agent required for such softening action should be a minimum.

The widespread use of synthetic detergents has complicated the situ-

(Continued on p. 400)

*For the original report, see "Metal Cleaning: I — Indirect Performance Tests", by Jay C. Harris, A.S.T.M. *Bulletin*, March 1945, p. 23; October 1945, p. 31.

Stuart's ThredKut

D. A. STUART'S THREDKUT straight, or in rich blend, provides fine finish on tough, stringy materials because its high sulphur content gives it excellent anti-weld characteristics.

In long dilutions THREDKUT delivers long tool life and outstanding performance at low cost on free cutting, high speed operations.

THREDKUT'S exceptionally broad range of usefulness makes it cost less than "cheaper" products in the majority of cases and often eliminates the need for several different types of oils. When it comes to *performance* on the jobs within its range, *none can best it!* Write for details and literature.

100% of All Metal Cutting Jobs Can Be Done at Lower Cost with D. A. Stuart's Wise Economy Plan *Ask about it!*

OUR 85th YEAR

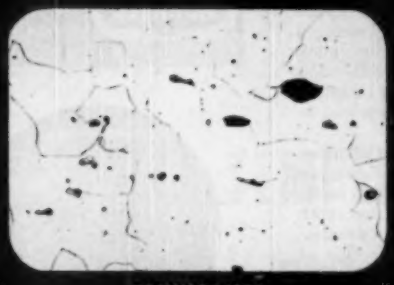
D. A. Stuart Oil Co.

2743 South Troy Street, Chicago 23, Illinois

Now You Can Get **GAS FREE HIGH PURITY METALS** in ingot form

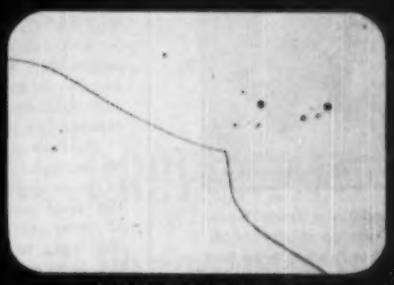
Typical Analysis
10 Pound
Iron Ingot

Nitrogen	< 0.001%
Hydrogen	<0.0001%
Oxygen	< 0.02%
Aluminum	< 0.001%
Carbon	< 0.005%
Chromium	< 0.001%
Columbium	< 0.001%
Copper	< 0.001%
Manganese	< 0.001%
Molybdenum	< 0.001%
Nickel	< 0.001%
Phosphorous	< 0.005%
Silicon	< 0.01%
Sulphur	< 0.005%
Tin	< 0.001%
Titanium	< 0.001%
Tungsten	< 0.001%



ORDINARY IRON

Note the heavy distribution of oxide inclusions resulting from oxygen content of 0.1% Magnification 500 X



GAS FREE HIGH PURITY IRON

Note the minute oxide inclusions resulting from vacuum processing to obtain an oxygen content of 0.02% Magnification 500 X

National Research Corporation, as a result of years of experience in the operation of metallurgical processes at pressures of 0.001 millimeters of mercury and less, is now supplying Gas Free High Purity Metals which have been melted and cast under the most perfect conditions for exclusion of occluded gases, accurate control of composition, and maintenance of uniform properties.

For the research laboratory requiring metals of the highest purity with minimum gas content, National Research Corporation will supply Gas Free High Purity Iron in 10 pound ingots from stock. Other metals including copper, cobalt, and nickel are similarly available. Special alloys, held to extremely close composition tolerances, may be produced on order.

Ingots up to 200 pounds will be supplied to users who desire to carry out larger experimental operations or production runs requiring materials of the highest quality. Arrangements can be made to supply Gas Free High Purity Metals in sheet, strip, and wire form.

Write for further particulars on specifications, prices, and delivery schedules.

INDUSTRIAL RESEARCH · PROCESS DEVELOPMENT · HIGH VACUUM ENGINEERING AND EQUIPMENT

METALLURGY · DEHYDRATION DISTILLATION COATING · APPLIED PHYSICS

National Research Corporation

Seventy Memorial Drive, Cambridge, Massachusetts

In the United Kingdom: BRITISH-AMERICAN RESEARCH, LTD., London S. W. 7, England — Glasgow S. W. 2, Scotland

YOUR HARDNESS TESTER . . .

IS ONLY AS GOOD AS THE DIAMOND IT USES

Standard "C" Diamond Cone
$18.00 F. O. B. Detroit

Dependably accurate "Rockwell" testing results are obtained only when every part of your hardness testing equipment is made to precision limits. That is why a correctly designed diamond penetrator is of such great importance. Always specify CLARK Diamond Cone Penetrators, both for Standard and for Superficial "Rockwell" testing. They are accurately made to the proper size and shape; exactly formed by expert lappers. CLARK Penetrators are designed for use on all "Rockwell" type testing machines.

CLARK
TOMORROW'S ACCURACY TODAY

INSTRUMENT, INC.
10200 FORD ROAD
DEARBORN, MICH.

Metal Cleaning

(Starts on p. 339)

ation, since many are very slightly affected by hard water, while soap readily forms insoluble and sticky curds. This indicates the use of one of three tests: *(a)* when soap and synthetic agent are absent, *(b)* when soap alone is present, and *(c)* with synthetic detergent alone or mixed with soap.

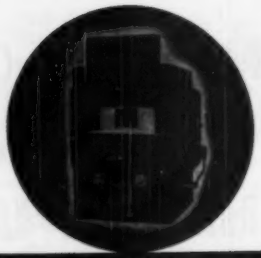
Conductivity — Methods for measurement are available and a practical method for test can be used. The higher the conductivity, the greater the evolution of gas and the more rapid the cleaning process. The current-carrying capacity seems to be more important in cleaning steel than the softer metals using milder cleaners with less vigorous action.

Solvent Action — This is a specific property but apparently of considerable value. Certain types of soil may be removed most effectively, safely or economically by solvent or vapor-degreasing, or by emulsion degreasing. Such action can be determined best by actual trial or, for example, by coating a 3 x 6-in. anodized aluminum alloy panel with S.A.E. No. 50 oil, completely immersing in the solution and observing the time required to remove the oil.

Surface and Interfacial Tension Measurements — Surface tension can be measured by capillary rise or by the drop weight method, but both of these methods require considerable care in manipulation. One of the simplest and most rapid methods of measurement is the use of the DuNouy tensiometer, which is a method required by numerous Government specifications. Interfacial tension measurements can be determined in several ways. The DuNouy ring apparatus is the most rapid.

Emulsification — Tests are very specific but of value. It is important that the detergent be stable to water and to extreme dilution with Stoddard solvent, kerosene or other organic solvent used. In soak cleaner baths adequate emulsification is important, to prevent the greases, oils and other contaminants from floating to the surface and contaminating the pieces at the time of withdrawal. Two general types of test are indicated: *(a)* to determine the stability of emulsion cleaners to dilution and to water, and *(b)* for aqueous cleaning baths either on dilution or overloading.

(Continued on p. 402)



BURRELL
BOX and MUFFLE
FURNACES

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC BOX and MUFFLE FURNACES for melting, sintering, heat treating, ignitions, etc.

Write for Bulletins 315 and 515.

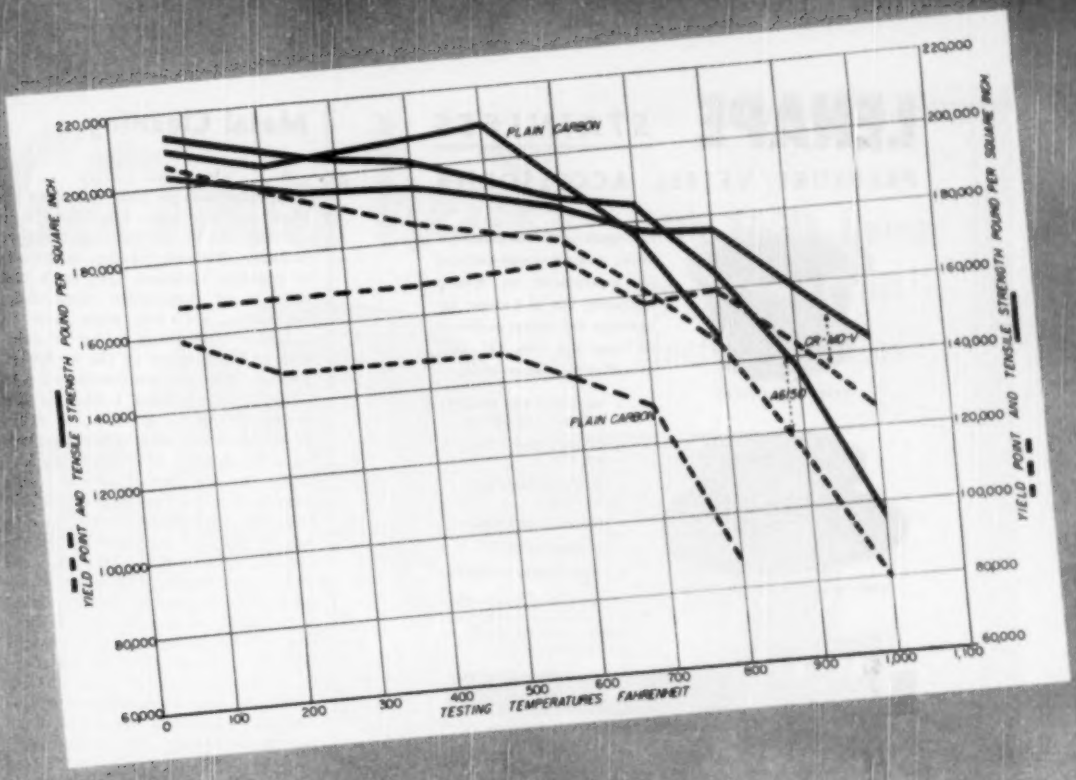
BURRELL
1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA

BURRELL
TUBE FURNACE

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC TUBE FURNACES for determination of carbon or sulfur by combustion and for experimental or production purposes.

Write for bulletin 310.

BURRELL
1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA



HIGH TEMPERATURE PROPERTIES

of Cr-V and Cr-Mo-V Spring Steels

SPRINGS FOR SERVICE at elevated temperatures require steels which resist softening and lowering of the yield point. Unless hardness and yield strength are stabilized by correct alloy additions to the steel, these properties deteriorate rapidly as the temperature is raised.

The chart above shows the yield point and tensile strength of three types of spring steel at elevated temperatures determined by standard short-time tension tests.

Springs of plain carbon steel are sometimes used at moderately elevated temperatures, although their lower yield values prevent them from giving service as satisfactory as that of the alloy spring steels.

Chromium-vanadium steel springs, such as AISI 6150, give better service at ordinary temperatures because of the higher yield point. In addition, they may be used at operating temperatures up to about 700° or 750° F because they retain high yield point values as the temperature is increased.

Chromium-molybdenum-vanadium steel was especially designed for springs operating at temperatures in excess of 750° F. It can be used for springs operating at temperatures as high as 850° F or even higher under some conditions. At 800° F, the yield point of this steel is still greater than that of plain carbon steel at room temperature.

If you have a problem in spring applications at elevated temperatures, our metallurgical engineers will be glad to help you solve it.

MAKERS OF ALLOYS — VANCORAM — CHEMICALS AND METALS

VANADIUM CORPORATION OF AMERICA

420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • DETROIT • CHICAGO • CLEVELAND • PITTSBURGH

LENAPE *STAINLESS*

PRESSURE VESSEL ACCESSORIES

TYPE "R" MANWAY

TYPE "R" NOZZLE WITH COVER

Designers and fabricators of tanks, pressure vessels and similar equipment are making increasing use of Lenape accessories and fittings produced in Types 304, 316, 347, etc., as well as the chrome-irons.

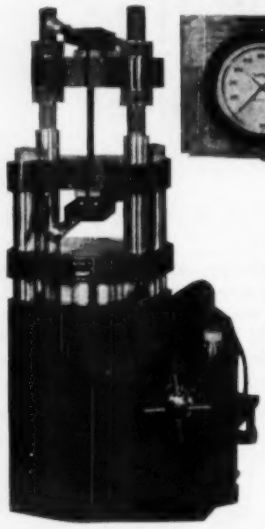
- HANDHOLE AND MANHOLE FITTINGS AND COVERS
- WELDING NECKS AND NOZZLES
- MANWAY NECKS AND NOZZLES
- SADDLES AND RINGS
- STUDDING OUTLETS
- PRESS-FORMED SPECIALTIES

Your prints and specifications will be given our prompt attention. Catalog 9-49 will be sent upon request.

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 109 WEST CHESTER, PA.

RED MAN PRODUCTS

A practical TENSILE TESTER FOR Spotwelds, Strip, Wire, etc.



This compact, 34" high machine is simple, accurate and fast to operate in the testing of tensile strengths up to 20,000 pounds. . . . An easily-controlled ram with handy specimen grips and adjustable pulling members give this tester its ease and speed of operation. . . . Various load gauges and grips are available for specific requirements.

A Card or Letter Will Bring Descriptive Literature

DETROIT TESTING MACHINE CO.
9390 Grinnell Avenue • Detroit 13, Michigan

Metal Cleaning

(Starts on p. 339)

Rinsability — This property is important and many tests have been devised, but it is difficult to measure suitably, because of the multitude of possible surfaces. One such test consists of completely suspending, for 5 min., a 4 x 6-in. glass panel in a beaker containing 1 liter of solution of the cleaner at 185 to 200° F. Remove and dip completely twice in a beaker containing 1 liter of tap water at 160° F., allowing to drain 10 sec. between dips. Observe presence or absence of "water breaks". Allow to dry for 2 hr. at room temperature at an angle of 45°. Observe any evidence of residue. Add a drop of c.p. alcohol to the surface, allow to evaporate, and notice any evidence of a white deposit. The absence of "water breaks" at the dip, and of a residue on drying, and the failure to form a white deposit on evaporation of the alcohol, indicate a suitably clean surface.

It may also be possible to utilize contact resistance measurement in the determination of cleanliness.

Stability Under Conditions of Usage — It appears that short of actual trial there is no readily applicable general test for this quality of a bath. The need is evident but development of a suitable test to evaluate this property is difficult because of the many types of soil and operating conditions involved.

None of the foregoing tests is to be considered as recommended by the American Society for Testing Materials, although many of them are in use as a means for controlling some desired quality.

Soil Removal Performance Tests

Laboratory methods for soil removal evaluation may be classified as follows: *(a)* oil removal, *(b)* solvent emulsion method, *(c)* electrolytic method, *(d)* carbon removal, *(e)* friction removal and *(f)* paint stripping.

Methods for estimating degree of soil removal are: *(a)* the ultraviolet measurement of retention of an oil-soluble fluorescent dye, *(b)* petroleum ether washing of the cleaned panel for removal of retained oil and *(c)* absence of waterbreak.

Measurement of soil removal by solvent emulsion may be visual, visual by comparison with the uncleaned portion, photometric

(Continued on p. 404)

Get more heats... with TASIL linings for your Detroit Electric Furnaces

Modern foundries are reporting outstanding results from TASIL linings in Detroit Electric Furnaces for melting grey iron, Ni-Hard and Ni-Resist, malleable iron and the complete range of copper-base, non-ferrous alloys. TASIL linings stand up for more heats with minimum patching, lowering the refractory cost per ton of metal melted.

TASIL refractories possess many desirable properties that increase furnace lining life. They have high hot load strength; high softening point (3335°); high volume stability throughout the temperature range; excellent resistance to spalling and slagging.

TASIL refractories are endorsed by the Detroit Electric Furnace Division, Kuhlman Electric Company and are made to their specification. TASIL brick and special shapes, as well as Patches and Cements specifically "engineered" for maintaining Detroit Electric Furnace linings are stocked for prompt shipment. See the Taylor representative in your area or write for details on how you can get more heats, and lower your furnace refractory costs with TASIL.

Refractorers to industry since 1864.

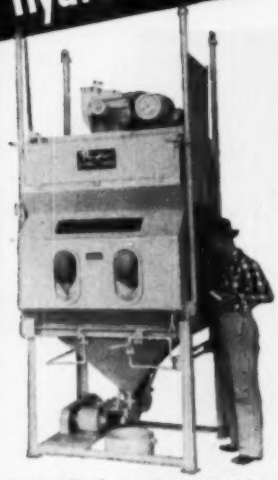
Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

The CHAS. TAYLOR SONS Co.

MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U. S. A.

Get BETTER PRODUCTS, LONGER TOOL and DIE LIFE with

PANGBORN "Hydro-Finish"



Better Products—Hydro-Finished surfaces electro-plate better, resist peeling. Hydro-Finish assures better bonding, makes threaded pieces turn easier, eliminates burrs and removes or blends grinding lines.

Longer Tool and Die Life—With Hydro-Finish you clean forging, forming, deep drawing and plastic dies, rubber and glass molds in minutes without excessive metal removal or expensive hand maintenance!

GET THE FACTS! Write today for Bulletin 1400 on Hydro-Finish to PANGBORN CORPORATION, 1204 Pangborn Blvd., Hagerstown, Md.

PANGBORNITE
The best abrasive for all liquid blasting needs. Available in many mesh sizes.

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment.

Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job

Metal Cleaning

(Starts on p. 339)

measurement of transmittance through glass, or by electrodeposition of copper on a cleaned steel panel.

A laboratory procedure useful for the evaluation of electrolytic metal cleaners has been developed by the Hanson-VanWinkle-Munning Co. They describe laboratory apparatus for the evaluation of either soak or electrified cleaners. The equipment provides for positive circulation (by pump) and an overflow bath. A titration method is recommended for determining the effective remaining alkali in the cleaning bath. Use of a laboratory centrifuge (to remove insoluble soil from the used cleaning bath), the control cleaning apparatus, and the titration analyses serve to decide the period at which the bath should be discarded.

The soil encountered in carbon removal is probably more tenacious than others. Consequently, some mechanical force may be required. The method for evaluation of results is generally direct comparison with an untreated panel or one which has been cleaned in a composition of known characteristics. Corrosion induced by the cleaning compositions may be a controlling factor in choice of detergent.

The term "friction removal" may be used to cover mechanical, manual, brush, or spray methods for soil removal. This type of soil removal has been segregated from the others simply because of the method used for evaluating the surface cleaners. Methods vary from visual inspection for evidence of an oil film, soap film or iridescence to the use of an appropriate photoelectric instrument.

Paint Stripping—The technique used in evaluation of products for this purpose falls into the metal cleaning category. The method is generally visual, for corrosive attack, oxidation, discoloration, and presence of stripping solution.

Measurement of Soil Removal—A difficult feature of the actual cleaning test is the determination of degree of effectiveness of soil removal. The test most commonly used, on the theory that a clean surface will be uniformly wetted by water, is the time-honored "water-break" method. The absence of "water-break" is taken as indication of absence of oily, water-

(Continued on p. 406)

A New Book ON

Machining

Theory and Practice

★

This 600-page volume is the result of a series of thirteen lectures presented during the Metal Show in Cleveland, Ohio, October 15-21, 1949.

Metal Cutting

Metal Cutting Research

Cutting Fluid Theory

Macrostructure of Metals by Machining

Materials and Machinability

Metallurgy and Machinability

Tool Steels

Cemented Carbide Tool Materials

Heat in Metal Cutting

Machinability of Rolled Steels, Forgings and Cast Iron

Tool Life Testing

Metallurgical Aspects of Grinding

Economics of Machining

OFF THE PRESS SOON
Order Your Copy Early
600 Pages .....6 x 9.....$6.50

★

AMERICAN SOCIETY *for* METALS

7301 EUCLID AVENUE
CLEVELAND 3, OHIO

Prepare now to enter the fifth

METALLOGRAPHIC EXHIBIT

to be held at the National Metal Congress and Exposition in Chicago, Oct. 23 to 27, 1950. Rules are simple and few; there are no restrictions as to size or method of mounting. A large area in the exhibition hall has been reserved so the entries can be displayed to best advantage.

RULES FOR ENTRANTS

Work which has appeared in previous Metallographic Exhibits held by the American Society for Metals is unacceptable.

Photographic prints shall be mounted on stiff cardboard, each on a separate mount. Each shall carry a label giving:

Name of metallographer
Classification of entry
Material, etchant, magnification
Any special information as desired

Transparencies or other items to be viewed by transmitted light must be mounted on light-tight boxes wired for plugging into an ordinary lighting circuit, and built so they can be fixed to the wall.

Exhibits must be delivered between Oct. 1 and Oct. 20, 1950, either by prepaid express, registered parcel post, or first-class letter mail.

Address: Metallographic Exhibit
c/o W. H. Eisenman
National Metal Congress and Exposition
International Amphitheater, Chicago, Ill.

CLASSIFICATION OF MICROS

1. Cast Irons and Cast Steels
2. Toolsteels (except Carbides)
3. Irons and Alloy Steels (excluding Stainless) in Wrought Condition
4. Stainless and Heat Resisting Steels and Alloys
5. Light Metals and Alloys
6. Heavy Nonferrous Metals and Alloys
7. Powder Metals (and Carbides) and Compacts
8. Weld Structures (including brazed and similar joints)
9. Series of Micros Showing Transitions or Changes During Processing
10. Surface Phenomena and Macrographs of Metallurgical Objects or Operations (2 to 10 diam.)
11. Results by Non-Optical or other Unconventional Techniques.

AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a first prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded to other photographs which, in the opinion of the judges, closely approach the winner in excellence.

A Grand Prize, in the form of an engrossed certificate, and a money award of $100 will be awarded the exhibitor whose work is adjudged "best in the show", and his exhibit shall become the property of the American Society for Metals for preservation and display in the Sauveur Room at the Society's Headquarters.

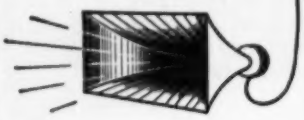
All other exhibits will be returned to owners by prepaid express or registered parcel post during the week of Oct. 29, 1950

Entrants living outside the U. S. A. will do well to send their micrographs by first-class letter mail endorsed "May be opened for customs inspection before delivery to addressee".

32nd NATIONAL METAL CONGRESS AND EXPOSITION

October 23-27, 1950

facts speak LOUDEST



At least one type of Molybdenum high speed steel is listed and promoted on a basis of equivalent and interchangeable performance with tungsten steel, by makers of high speed steel.

Users' reports of Molybdenum high speed tools *everywhere* indicate that performance at least equals and in many cases betters that of tungsten tools.

The heat treatment of Molybdenum high speed steels is basically the same as that of tungsten steels. There is nothing in the treatment to confound those who are familiar with the heat treatment of tungsten types.

Molybdenum high speed steels save money in production—for proof send for our FREE booklet.

Climax Molybdenum Company
500 Fifth Avenue · New York City

MAIL THIS COUPON

Please send me a copy of your FREE BOOKLET

Name .....

Company .....

Address .....

MP3-H82

MOLY

Metal Cleaning

(Starts on p. 339)

repellent contaminant. Recent information indicates, however, that preferential adsorption can take place at metal surfaces, with metals presenting a presumably "clean" surface because the adsorbed coating is "hydrophilic" — the opposite of water-repellent. The presence of such a film might be undesirable at a subsequent step in the manufacturing operation. Consequently, a more specific and sensitive test is called for.

A recent advance in the measurement of soil retention is that of Morgan and Lankler, who utilized a fluorescent dye, ultraviolet light, and photography. The sensitivity of the method was checked gravimetrically and the minimum amount of oil detectable (containing the fluorescent dye) was 0.000004 g. per sq.cm. of metal surface. Photometric means for measurement of reflectance are used in one method in which soil is partially or totally removed. The advantage of photometry is its rapidity and the fact that comparisons automatically become numerical.

Radioactive Tracers

The availability of radioactive compounds has made possible the measurement of traces of materials, which offers considerable promise in metal-cleaning studies. A test outlined by J. C. Harris, R. E. Kamp and W. H. Yanko (A.S.T.M. *Bulletin*, May 1949, p. 49) requires the use of a radioactive tracer compound compatible with an oily soil and not preferentially removed or adsorbed. The radioactive tracer technique is more sensitive than existent methods for estimation of soil removal and is quantitative in character.

The American Society for Testing Materials has published a standard method (D-930) entitled "Aluminum Cleaners, Water-Soluble, Total-Immersion Corrosion Test", and similar tests are being developed for metals other than aluminum. Also, attempts will be made to prepare performance tests for methods other than corrosion.

J. C. Harris has prepared a survey of the literature on metal cleaning, "Metal Cleaning Bibliographical Abstracts". This book, published by the American Society for Testing Materials, includes more than 500 references and abstracts about cleaning all kinds of metals.

Be Certain WITH "SERV-RITE"

THERMOCOUPLE INSULATORS

This Gordon Thermocouple Insulator, heated red hot and plunged into cold water, came out just as good as new

Available only through GORDON, Serv-rite Thermocouple Insulators are made to stand the gaff of excessive thermal shock far above normal requirements.

For sturdy and reliable thermocouple insulator performance to meet peak production needs — Specify Serv-rite...a Gordon development backed by 32 years' experience in supplying industry with insulators that last longer and give better results.

Serv-rite Thermocouple Insulators—in any type or size—can be supplied immediately from Gordon's large stocks in the Chicago and Cleveland Plants. Remember—you can always distinguish Serv-rite Insulators by their *tan* color.

Fish Spine Beads — Asbestos String
Asbestos Tubing — Single Hole
Double Hole Round — Double Hole Oval

CLAUD S. GORDON CO.
Specialists for 32 Years in the Heat Treating and Temperature Control Field

Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

Fundamental Mechanical Properties*

DR. BENEDICKS returns to a discussion of the relation between the basic properties of metals held in 1931 at the Zurich meeting of the International Assoc. for Testing Materials wherein it was evident that many workers in this field often used the same word but with different meaning. He attempts a graphic representation of the fundamental properties of metals, and says that the problem comprises the following points:

1. What are the simplest fundamental properties, sufficient to characterize materials from a mechanical point of view?

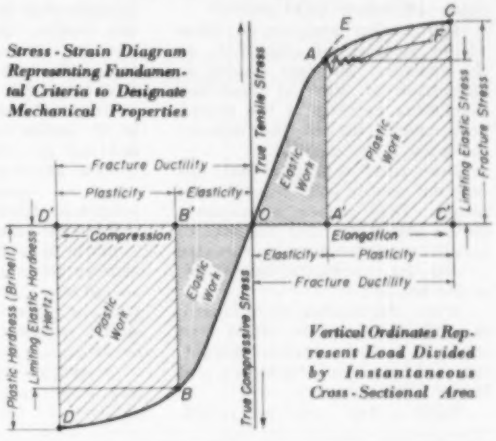
2. What would be the most adequate index of these fundamental properties?

In the accompanying figure the vertical ordinates are load divided by the instantaneous cross section. [Nothing is said about the gage length on which elongation is measured.]

It appears necessary to consider three separate cases: After moving elastically along *OA*, *(a)* a brittle material will fail along *AE*; *(b)* a material having an upper yield point will display complex stress-strain behavior beyond *A* and rupture at *F*; *(c)* an ordinary ductile material will strain along *AC* and rupture along *CC'*.

Case B — As a result of much previous work, of which the citations are given, it would appear that after elastic elongation a phenomenon takes place in metals having an upper and lower yield point that can be interpreted as a partial and reiterated rupture within the material; this phenomenon is followed by flow or deformation characteristic of a tough material. One can say that a metal having an upper yield point behaves as if it contained an interior framework or skeleton. As long as it is intact, the body supports a considerably higher load than that which it can support when the framework has been destroyed.

One might then ask, what is this framework in steel? Since high-carbon steels show the curve char-



Stress-Strain Diagram Representing Fundamental Criteria to Designate Mechanical Properties

Vertical Ordinates Represent Load Divided by Instantaneous Cross-Sectional Area

*Abstract from "What Are the Fundamental Properties Necessary to Describe the Mechanical Properties of Materials?" by Carl Benedicks (in French). *Revue de Métallurgie*, Vol. 46, No. 1, 1949. Translation by Wm. M. Baldwin, Jr.

BRITISH REFRIGERATION MANUFACTURERS

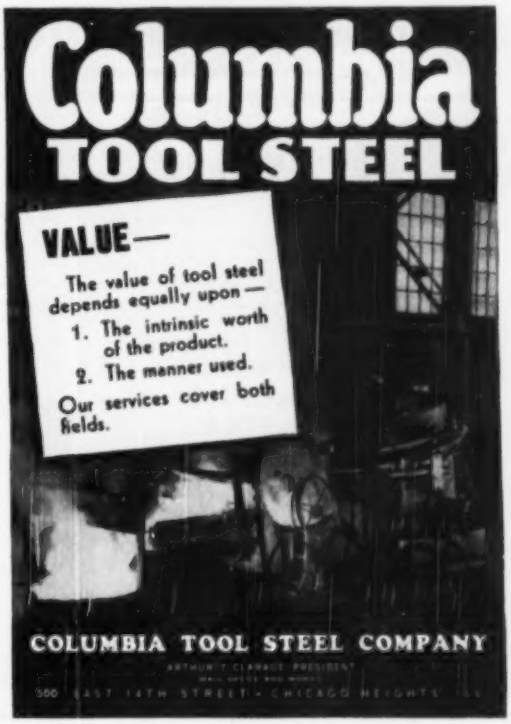
of Domestic Absorption Units operating on Bottle Gas, Kerosene and A.C. or D.C. Electricity, wishes to contact Domestic Refrigerator Box Manufacturer with a view to marketing a Domestic Refrigerator to the general public at approximately 100 dollars.

Those interested should contact company's export Director now in Canada and United States at the following address:

W. J. E. LEE (Export Director)
Le Bryan Group Products (Gt.B.) Ltd.,
c/o Manhattan Towers Hotel,
Broadway at 76th Street,
New York 24.

or

c/o **MR. BRESLIN**
Suite 3,
470 St. Alexis Street,
Montreal 1.


Columbia
TOOL STEEL
VALUE—
The value of tool steel depends equally upon—
1. The intrinsic worth of the product.
2. The manner used.
Our services cover both fields.
COLUMBIA TOOL STEEL COMPANY
500 EAST 14TH STREET • CHICAGO HEIGHTS

Fundamental Mechanical Properties

acteristic of *OAF*, provided there is a continuous network of cementite at the grain boundaries, this hard (strong) material can be regarded as the network. What, however, is the skeleton in soft, low-carbon steels that have a characteristic stress-strain curve with upper and lower yield points?

One cannot suppose a microscopic network of cementite; on the contrary, we must assume an absorption of different impurities (including carbon) at the boundaries, which harden and stabilize the grain boundaries.

One must conclude that this does not exist in truly homogeneous metals. They possess stress-strain curves like *OAC*. (For the sake of completeness, the curve is repeated — with the coordinates inverted — in the left half.)

When the tension is increased, the relation between stress and strain is at first virtually straight, followed by a sharp curvature, and finally a flat curvature.

Point *A* has a special significance: It represents the maximum tension (as well as the maximum elongation) which the specimen can support without permanent (irreversible) deformation. This means that along the length of *OA*, the material behaves elastically. This is why *A* is called the "elastic limit".

Beyond *A* the elongation is irreversible. But the irreversible elongation can appear in two fundamentally different ways. It is possible that at *A* immediate rupture occurs, as indicated by the line *AA'* which indicates that the tension is abruptly relieved and by line *A'O* which indicates an abrupt contraction leaving the specimen at its initial length. This is the behavior of a "brittle" material.

The other possibility occurs when, on passing *A*, there is an extension of the body involving an irreversible elongation along *AC*. It is not until point *C* is reached that rupture occurs, marked by the abrupt line *CC'* and a certain retrogression which corresponds to an elastic contraction. This is the behavior of a ductile material.

A succinct but adequate description of the complete curves can be obtained by knowing the position of the points *A* and *C* — that is, by knowing four different parameters, of which two refer to stress and two to strain.

Tensile Parameters

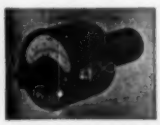
Stress — The ordinate of point *A* represents the maximum stress which the body can resist without permanent deformation. It can properly be designated as the "limiting elastic stress".

The ordinate of point *C* is obviously the "fracture stress", the maximum stress that the body can support after a certain deformation before rupture or discontinuous deformation.

Strain — The abscissa of point *A* represents the maximum elongation that the body can undergo without permanent deformation. This elongation corresponds nicely with the term "elasticity" — an exact definition for something which now is used somewhat vaguely. The word elasticity should be equivalent to elastic elongation.

The abscissa of point *C* represents the maximum elongation that the body can undergo without rupture, and is the sum of the elastic elongation and the plastic elonga-

WHY GUESS THE TEMPERATURE
. . . when you can see it!



THE NEW PYRO RADIATION PYROMETER

Tells spot temperatures instantly in heat-treating furnaces, kilns, forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature is indicated on direct-reading dial at a press of the button. Any operator can use it. In two double-ranges for all plant and laboratory needs. *Write for FREE Catalog No. 100.*

Just sight it . . . and press the button!

PYRO OPTICAL PYROMETER

Accurate temperatures at a glance!

Determines temperatures of minute spots, fast moving objects or smallest streams — accurately, rapidly. No correction charts or accessories needed. Easy to operate — weighs only 3 lbs. Special types available to show true spout and pouring temperature of molten metal in open. In 5 temperature ranges. *Write for FREE Catalog No. 80.*

THE PYROMETER INSTRUMENT COMPANY
New Plant and Laboratory
Bergenfield 8, N. J.

Quality - - -

at a reasonable price

This metallographic polisher has three spindles set in a table 28" by 63". The three speed spindles have individual, torque-increasing V-belt drives. The polisher is complete with two faucets and monel wash bowls. Cat. No. 53-474 sells for $725. Request Bulletin 90 showing all models of Eberbach metallographic polishers.

Eberbach & Son Company
Ann Arbor, Mich.
Laboratory Apparatus & Supplies

tion. This corresponds nicely to the concept of "fracture ductility".

In any case, one has

$$\text{Fracture Ductility} = \text{Elasticity} + \text{Plasticity}$$

Under this system the idea of brittleness — a quantity that is not measured by direct methods — could very rationally be thought of as an inverse quantity of fracture ductility, that is,

$$\text{Brittleness} = \frac{1}{\text{Fracture Ductility}}$$

analogous to the inverse relationship existing between electrical conductivity and resistivity.

Compression

The general shape of the curve *OBD* for compression is in principle a mirror of the curve *OAC* in tension; differences exist because of differences in experimental techniques.

The four parameters or fundamental properties are as follows:

Stress — The ordinate of *B* represents the maximum compressive stress that the body can support without permanent deformation. It is the physical property which is Hertz's criterion for hardness — namely, the compressive stress exerted on the surface of a brittle material at the moment of formation of a crack. It can be designated as the "limiting elastic hardness".

The ordinate of *D* represents the maximum compressive stress that a body can support — after a continuous deformation along *BD* — without discontinuous deformation. This stress virtually coincides with the Brinell hardness and can be designated "plastic hardness". (This identity is not perfect. A Brinell test actually does not give the exact point *D* where incipient cracks are forming, but rather a part of curve *DB* in the neighborhood of *D*. The low slope of the curve implies that the tensile stresses of the plastic hardness change only slightly.)

Strain — The abscissa of *B* represents the maximum compressive strain that the material can undergo without permanent deformation. This corresponds so well to the term "elasticity" as above defined that we state: "Elasticity is the maximum elongation or compression that a metal can undergo without permanent deformation." The elastic modulus, that is to say the slope of the line *AOB* at the origin, is evidently the same for elongation as for compression.

The abscissa of *D* represents the maximum compressive strain that the body can undergo before the appearance of fissures. It is the sum of the elastic and plastic compressions and corresponds to "fracture ductility", as indicated in the diagram.

The Complete System

The complete system of fundamental properties can therefore be summarized thus:

Tension

I. Stress parameters
   1. Limiting elastic stress
   2. Fracture stress

II. Strain parameters
   1. Elasticity
   2. Fracture ductility

Compression

I. Stress parameters
   1'. Limiting elastic hardness (Hertz-Auerbach)
   2'. Plastic hardness (Brinell)

II. Strain parameters
   1'. Elasticity
   2'. Fracture ductility

Consult This Volume with Confidence —

Mechanical Wear

Edited by John T. Burwell, *Associate Professor*
Department of Mechanical Engineering
Massachusetts Institute of Technology

TWENTY-TWO EXPERTS . . . American, British and Dutch . . . discuss this complex subject in a book that is destined to become a standard reference work.

A. L. Boegehold, Head, Metallurgy Dept., General Motors' Research Laboratories, says: ". . . very instructive collection of papers on the subject of wear in general . . . the latest thinking on the subject."

Red Cloth Binding — Well Illustrated
375 Pages.....6 x 9.....$6.50

American Society for Metals
7301 Euclid Ave., Cleveland 3, Ohio

LEPEL presents 2 New UNITS FOR HIGH-FREQUENCY HEATING
NEW SPARK-GAP UNIT
A completely redesigned unit available in 7½, 15 and 30 KW input ratings. All-steel housing with interiors of the latest fire-resistant materials. Convenient operating controls, modern appearance.
Unit can be used for heating or melting without matching transformers or condensers. Delivers full rated output when treating ferrous or non-ferrous materials. Minimum power and water consumption.
NEW VACUUM-TUBE UNIT
The last word in high frequency heating equipment of the electronic tube type, incorporating the latest improvements in its all-steel housing.
Effectively heats ferrous or non-ferrous metals for hardening, soldering, brazing or melting applications. Easily adjusted to any load . . . does not require matching transformers or condensers. Minimum power and water consumption. Units conservatively rated at 5, 10, 20, and 40 KW output.
HARDEN
SOLDER
Lepel
HIGH FREQUENCY HEATING UNITS
BRAZE
MELT
LEPEL HIGH FREQUENCY LABORATORIES, Inc., 39 West 60th Street, New York 23, N. Y.

Write for LEPEL Catalogue MP-3

Chromium Plating*

CHROMIUM PLATING is widely used to provide a hard wear resistant coating on machine parts and for decorative purposes on such products as automotive grillwork and bathroom fixtures. For commercial plating of this kind, the chromic acid bath, first reported in 1856, is at present virtually the only chromium plating solution in use. This bath is prepared by dissolving chromic acid anhydride (CrO_3) and a little sulphuric acid in water. Initially, all the chromium in the solution is in the hexavalent state; but when the plating current is applied, some trivalent chromium is formed by reduction of the hexavalent chromium at the cathode. This has led to numerous investigations into the mechanism of the electrodeposition process, to determine whether the chromium is deposited directly from the hexavalent state or through the intermediate formation of trivalent ions.

The experiments of Ogburn and Brenner involved electrodeposition of chromium from chromic acid electroplating baths to which traces of radioactive chromium had been added. The results showed that the chromium is deposited directly from the chromate ion. This has frequently been assumed but until now the mechanism of forming the electrodeposit has not been clear. It would be extremely difficult to follow the course of the deposition by any other method than through the use of tagged atoms.

The tracer used was chromium 51 (Cr^{51}) which is a soft gamma ray emitter of 26.5 days half-life. The tracer was produced at the Oak Ridge National Laboratory by irradiating small pellets of pure chromium metal with neutrons in the nuclear reactor (uranium pile). After receipt from Oak Ridge, the irradiated pellets were converted to chromic chloride, $CrCl_3$, and to sodium chromate, Na_2CrO_4, for additions to the standard electroplating bath. The presence or absence of the radioactive chromium in the bath and in the electrodeposited metal was determined by use of a thin-walled glass gamma-ray counting tube and accessory equipment.

After demonstrating that exchange between the trivalent chromium and the hexavalent chromium ions was negligible, at 55° C., electrodeposits were made (on brass) with nonradioactive trivalent chromium introduced into the bath by three methods: *(a)* electrolytic reduction of chromate, *(b)* added as hydrated chromic oxide and *(c)* added as chromic chloride. Porous partitions were used in the cells to prevent anodic oxidation of trivalent chromium during electrolysis, and the experiments were performed rapidly to keep isotopic exchange between the ions at a minimum. When the activity was added as trivalent Cr^{51} to baths prepared in these three ways, the electrodeposit showed no activity; but when added as hexavalent Cr^{51}, the plated metal was radioactive. Upon removal of the porous partition, thus permitting the trivalent Cr^{51} to undergo electrolytic oxidation at the anode, the electrodeposit on the cathode became progressively more radioactive.

Thus, the theory is confirmed that in the particular chromic acid baths used, deposit is directly from the hexavalent chromium present in the bath and not through the intermediate formation of trivalent or divalent chromium ions.

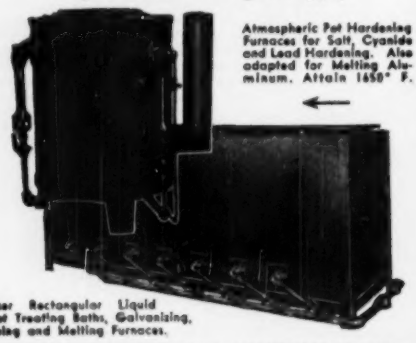
*Abstract of "Experiments in Chromium Electrodeposition With Radioactive Chromium", by F. Ogburn and A. Brenner, *Journal of the Electrochemical Society*, Vol. 96, Dec. 1949, p. 347.

✓ PLAN TO INSTALL

BUZZER
Reg. U.S. Pat. Off.

INDUSTRIAL *Gas* EQUIPMENT

NO BLOWER or POWER NECESSARY
. . . just connect to gas supply



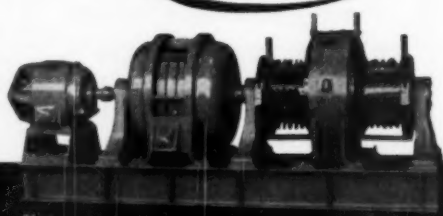
Atmospheric Pot Hardening Furnaces for Salt, Cyanide and Lead Hardening. Also adapted for Melting Aluminum. Attain 1650° F.

Buzzer Rectangular Liquid Heat Treating Baths, Galvanizing, Tinning and Melting Furnaces.

Send for the complete "BUZZER" Catalog

CHARLES A. HONES, INC.
123 So. Grand Ave. Baldwin, L. I., N. Y.

Motor Generators
by COLUMBIA



For
Electroplating — Anodizing
Electrocleaning — Electropolishing

There's a Columbia M-G Set available for your needs, whether you have a small plating bath or a large continuous strip plating line. Capacities up to 20,000 Amperes; 6 Volts and up. Dependable performance proved for many years. Your inquiries solicited.

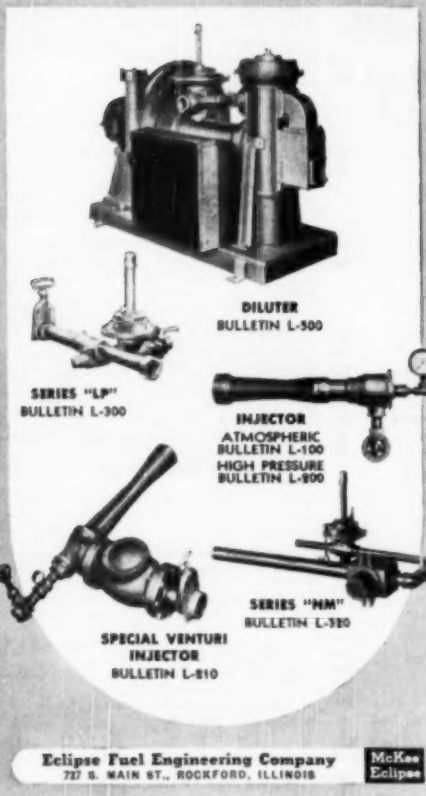
Write today for Catalog MP-700

COLUMBIA ELECTRIC MFG. CO.
4531 HAMILTON AVENUE CLEVELAND 14, OHIO

FOR EFFICIENT AIR GAS RATIO CONTROL

McKEE AIR-GAS PROPORTIONAL MIXERS

McKee Proportional Mixers are designed for all industrial applications. They're adjustable to handle changes in heat content or specific gravity of a wide variety of gaseous fuels . . . they're flexible for use with a range of gas or air pressures . . . they're automatic to provide a correct combustion ratio at all times. Ask for full information on these dependable, economical mixers.



Eclipse Fuel Engineering Company
727 S. MAIN ST., ROCKFORD, ILLINOIS
McKee Eclipse

When it's a Question of

RESISTANCE

to HEAT *and* CORROSION?

PYRASTEEL... is the Answer

PYRASTEEL Conveyor Screw, at right, gave *370 days'* continuous service in a cement plant . . . nearly 40 times as long as the previous carbon steel screws.

This is typical of the long, economical service of PYRASTEEL . . . "costs less per heat hour".

PYRASTEEL is a chrome-nickel-silicon alloy that provides maximum resistance to oxidation and corrosion at temperatures up to 2000° F. It also resists gases and most concentrated or dilute commercial acids.

PYRASTEEL puts long life into parts for which it is used. It has a wide range of high-heat applications, including furnace construction, conveyor screws, annealing pots, grids and guides, food and chemical processing equipment, and refinery valves and fittings.

•

Write for PYRASTEEL Bulletin

•

CHICAGO STEEL FOUNDRY CO.
Kedzie Ave. and 37th Street • Chicago 32, Illinois
Makers of Alloy Steel for Over 40 Years

METAL PROGRESS

A. P. FORD, *Advertising Manager*; GEORGE H. LOUGHNER, *Production Manager*
7301 Euclid Ave., Cleveland 3—UTah 1-0200

ROBERT S. MULLER, *Eastern Manager*
55 W. 42nd St., New York 18—CHickering 4-2713

DON HARWAY, *Pacific Coast, 1709 West 8th St., Los Angeles 14—DUnkirk 2-8576*

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

• Index to Advertisers •

Acheson Colloids Corp. 373
Air Reduction Sales Co. 380
Ajax Electric Co. 273
Ajax Electrothermic Corp. 297
Ajax Manufacturing Co. 288
Alloy Casting Co. 363
Aluminum Company of America 275
American Chemical Paint Co. 364
American Cyanamid Co. 383
American Gas Furnace Co. 388
American Hot Dip Galv. Assn. 390
American Society for Metals, 396, 404, 405, 409
Austenal Laboratories, Inc. 316

Baldwin Locomotive Works 310
Barrett Division, Allied Chemical & Dye Corp. 386
Bausch & Lomb Optical Co. 348D
Bell & Gossett Co. 302
Bethlehem Steel Co. 379
Bristol Co. 377
Brown Instrument Co. 371
Buehler, Ltd. 276
Burrell Co. 400

Carborundum Co. 294
Carlson, Inc., G. O. 375
Cerium Metals Corp. 394
Chicago Steel Foundry Co. 411
Cities Service Oil Co. 315
Clark Instrument, Inc. 400
Climax Molybdenum Co. 406
Columbia Electric Mfg. Co. 410
Columbia Tool Steel Co. 407
Copperweld Steel Co. Back Cover
Crucible Steel Co. of America 283

Delaware Tool Steel Co. 390
Detroit Testing Machine Co. 402
Dow Chemical Co. 389
Driver-Harris Co. 385

Eastman Kodak Co. 365
Eberbach & Son Co. 408
Eclipse Fuel Engineering Co. 411
Electric Furnace Co. Inside Back Cover
Electro Alloys Co. 290
Electro Metallurgical Division, Union Carbide & Carbon Corp. 313
Enthone, Inc. 291

General Alloys Co. 397
General Cerium Co. 392
General Electric Co. 395
Gordon Co., Claud S. 311, 406
Gray Iron Founders' Society, Inc. 284
Great Lakes Steel Corp. 295
Gulf Oil Corp. 305

Heatbath Corp. 348C
Hevi Duty Electric Co. 282
Holcroft & Co. 384
Hones, Inc., Chas. A. 410
Hoskins Mfg. Co. 369
Houghton & Co., E. F. 367

Inland Steel Co. 320
International Nickel Co., Inc. 278, 348A

Johns-Manville 279
Jones & Laughlin Steel Corp. 306

Kemp Mfg. Co., C. M. 374
Kux Machine Co. 314

Lakeside Steel Improvement Co. 392
LaSalle Steel Co. 300
Latrobe Electric Steel Co. 270
LeBryan Groups Products 407
Leeds & Northrup Co. 271
Lenape Hydraulic Pressing & Forging Co. 402
Lepel High Frequency Labs. 409
Lindberg Engineering Co. 281

McKay Co. 287
Michigan Steel Casting Co. 304
Mitchell-Bradford Chemical Co. 366

National Carbon Division, Union Carbide & Carbon Corp. 381
National Research Corp. 399
Northwest Chemical Co. 286
Norton Co. 318

Ohio Crankshaft Co. 269
Ohio Ferro-Alloys Corp. 272
Olsen Testing Machine Co. 312

Pangborn Corp. 404
Park Chemical Co. 368
Peterson Steels, Inc. 394
Pittsburgh Steel Co. 293
Pressed Steel Co. 296
Pyrometer Instrument Co. 408

Republic Steel Corp. 277
Revere Copper & Brass, Inc. 361
Riverside Metal Co. 301
Rockwell Co., W. S. 388
Rolock, Inc. 299

St. Joseph Lead Co. 298
Sentry Co. 362
Sharon Steel Corp. 389
Spencer Turbine Co. 285
Standard Alloy Co., Inc. 370
Steel City Testing Machines, Inc. 398
Stuart Oil Co., D. A. 398
Sunbeam Stewart Industrial Furnace Div. 292
Surface Combustion Corp. Inside Front Cover

Taylor Sons Co., Charles 403
Timken Roller Bearing Co. 303
Titanium Alloy Mfg. Co. 274
Tracerlab, Inc. 378

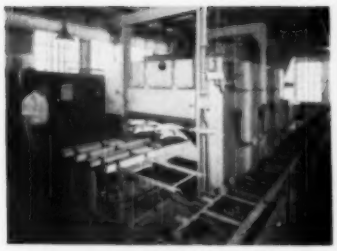
Union Carbide & Carbon Corp. 313, 381
United Chromium, Inc. 307
United States Pipe & Foundry Co. 391

Vanadium-Alloys Steel Corp. 387
Vanadium Corp. of America 401

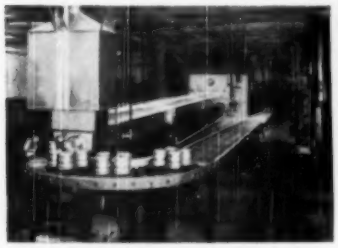
Westinghouse Electric Corp. 393
Wheelco Instruments Co. 388
Wheelock, Lovejoy & Co., Inc. 382
Wilson Mechanical Instrument Co. 372
Wisconsin Steel Co. 289

Youngstown Sheet & Tube Co. 280

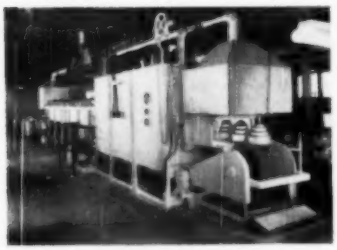
TOWER PRESS
CLEVELAND



Brazing and Heat Treating Aluminum. Above picture shows the charging end of an EF aluminum brazing and heat treating furnace of the straight-thru type in which the assemblies are loaded on trays and are advanced thru three separate chambers for brazing, solution treatment and forced cooling.

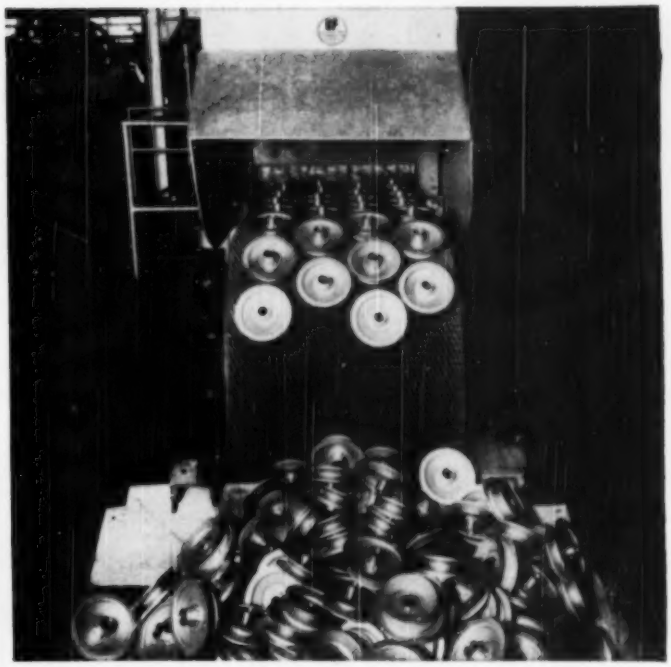


Copper Brazing Heavy Assemblies. This EF Roller Hearth Furnace brazes large steel assemblies which are carried thru directly on the rollers or on trays, and emerge as integral units — scale-free, bright, and undistorted — ready for use. Similar furnaces handle brass, aluminum, copper and other ferrous and non-ferrous products.



Brazing and Bright Annealing. EF Continuous Mesh Belt Conveyor furnaces are used extensively for brazing, bright annealing, drawing and other high and low temperature heat treating processes. The material is loaded directly on the woven wire conveyor belt, uniformly processed and discharged, automatically.

EF Brazing Furnaces may be Gas Fired or Electrically Heated



EF BRAZING FURNACES

cut material, tooling and finishing costs

● The material required, for instance, when brazing a disc on the end of a tube may be 75% to 80% less than if the hollow flanged part is cut from the solid. This means substantial machine and labor savings. Finishing costs are low too, because the assemblies are discharged from the furnace smooth and free from scale.

The fillets along the joint, and the high shear strength of the alloy in the joint, prolong the life of assemblies that are subjected to vibration and impact. Brazing avoids localized overheating, distortion, and the cost of straightening. Consequently the process is ideally used for joining hollow articles such as floats, pulleys, etc.; and is readily adaptable to most any size and shape, and weight and quantity requirement.

To get maximum results, let EF engineers, with their wide experience, work with you on your next brazing job. Fully descriptive folders including many suggested "do's" and "don'ts" sent promptly on request.

THE ELECTRIC FURNACE CO.

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Salem - Ohio

ARISTOLOY STEELS

HIT THE MARK

ARISTOLOY STEELS

- STANDARD STRUCTURAL ALLOY
- BEARING QUALITY • ALLOY TOOL
- SPECIALTY • NITRALLOY
- CARBON TOOL • STAINLESS
- MAGNAFLUX – AIRCRAFT QUALITY

COPPERWELD STEEL COMPANY, WARREN, OHIO

117 Liberty Street New York, New York	1578 Union Commerce Building Cleveland, Ohio	529 Fisher Building Detroit, Michigan
176 W. Adams Street Chicago, Illinois	7251 General Motors Building Detroit, Michigan	3104 Smith Tower Seattle, Washington
P. O. Box 1633 Tulsa, Oklahoma	403 W. Eighth Street Los Angeles 14, California	Monadnock Building San Francisco 5, Calif.